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International Joint Conference of The American Geographical Society and The American Division of The World Academy of Art and Science

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Volume 184

June 7, 1971

ENVIRONMENT AND SOCIETY IN TRANSITION

Editors

PETER ALBERTSON AND MARGERY BARNETT

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PREFACE

It is somewhat unusual in preparing a collection of this nature to depart from the more formal proceedings of a scientific conference. That is, one expects to find a speaker's paper, then a discussion of that paper, and so on. Because that was not the approach here, a word of explanation is in order.

Participants in the International Joint Conference on Environment and Society in Transition were asked to submit papers in advance of the meeting, and to be prepared to participate in the Plenary Sessions and Working Group discussions. At times, portions of the Plenary Session discussion were actually the oral transmission of a participant's prepared paper; in those instances, the editors have inserted the advance papers in place of the oral presentations. We decided to publish the remaining advance papers immediately following the Plenary Sessions for which they had been prepared, to maintain the flow and unity of the Conference.

Authors of papers had the opportunity to approve our editorial changes, but, because discussions were so wide-ranging and because so many discussants took part, we were unable to submit edited transcripts to each participant. Therefore, any errors of omission or commission in the discussion sections are the fault of the editors alone, for which we apologize.

We would like to note here that, because of unavoidable circumstances, some sessions were not recorded; others were recorded only in part. When a session was not recorded, or when substantial portions of the transcript were not used for one reason or another, such omission is noted in a footnote to that Working Group's session.

Throughout, we have attempted to render a readable account of oral participation. We are grateful to the Editorial Committee of the International Joint Conference for their confidence in our ability to organize and edit the proceedings. We are grateful, too, for their approval of our proposal to keep the exciting quality of lively oral debate during the discussions in both Plenary Sessions and Working Groups.

Our thanks, especially, to Boris Pregel and John McHale, to Harold Lasswell and Stuart Mudd, who were understanding and patient through long delays, confusions, and myriad editorial difficulties. We believe these proceedings of the International Joint Conference of the World Academy of Art and Science and the American Geographical Society on Environment and Society in Transition is really their book.

We also wish to thank Mrs. Caroline Antonucci and Mrs. Joyce Fucile for their yeoman service in retyping a long and heavily edited manuscript, and Louis Doyle for his conscientious copy editing.

Peter Albertson
Margery Barnett
New York
February, 1971

FOREWORD

Boris Pregel, Harold Lasswell, John McHale

The Conference whose papers, discussions, and proposals are presented in this volume is a transnational and transdisciplinary undertaking the significance of which is to be understood by examining its relationship to what has gone before and to the probable steps that will be taken in the immediate and more remote future to connect scientific knowledge with public policy.

In widest perspective the Conference in New York expresses the cumulative concern of scientists and the public at large for the social consequences and policy implications of scientific knowledge. More narrowly the undertaking is to be seen as a continuation of the meetings of the World Academy of Art and Science (WAAS, established 1960) in Brussels (1961), in Stockholm (1963), and in Rome (1965). By previous arrangement, it also continues the discussion at the Nobel Symposium 14 (Stockholm, 1969), "The Place of Value in a World of Facts." A number of members of the New York gathering participated in both meetings.

The immediate initiatives for the consideration of Environment and Society in Transition came from the American Division of the World Academy and the American Geographical Society (established 1852), which is one of the oldest scientific societies in the United States. The premises of The New York Academy of Sciences were the scene of the Conference.

The planning of the New York meeting was begun before the scientific community, the American public, or the public of other countries suddenly became aware of the environmental crisis. It was far from trite, for instance, to assert that we are past the eleventh hour in the pollution of many of the principal components of our system of lakes, surface rivers, and underground waters. Or that creeping congestion spreads from the core of urban aggregates, and endangers the psychic stability no less than the physical integrity of human society. Without exaggerating the role of the preparatory work for the New York Conference, there is evidence of the influence of the preliminary memoranda—which were privately circulated among certain international scientific bodies and official agencies—on the content of many meetings and programs.

Such immediate side effects were welcome indicators of opportune timing of the undertaking. They did not, however, divert the Conference planners from long-range or middle-range objectives. The planners were aware of the perils that usually attend bursts of general enthusiasm on behalf of belated programs of public policy. Insufficiently aware of the complex and delicate nature of ecological balance, programs of superficial plausibility may eventually leave us in a worse state than we are at present.

If the profound policy implications of scientific knowledge for "Environment and Society" are to be grasped, more than an ephemeral and topical approach is essential. The plan therefore was to bring together a Conference whose members would be representative of the best that the contemporary world of science has to offer. There is no question that, in so far as several relevant disciplines are concerned, this objective was achieved.

We sometimes refer to the New York meeting as a "microconference." It was indeed a micro- rather than a macroconference when it is compared with

the many thousands of participants who are often invited to an international scientific gathering. The hope was that a modest size—not much in excess of a hundred—would be conducive to an intellectual experience that would be at once broader and deeper than usual.

As a means of providing such an experience, several procedural innovations were introduced. If an "interdisciplinary approach" is to be realized in fact as in name, interdisciplinary exposures must be provided for all who seek to think and act together. We therefore devoted Part I of the Conference to an authoritative review of the present state of knowledge in the principal fields into which intellectual inquiry is usually divided. The intellectual task of each contributor was indeed formidable. As a selective guide he was asked to consider the most significant developments that have occurred in his field of competence as they relate to society and environment in these transitional times. It was necessary for him to consider conceptual and procedural developments, as well as accepted findings, that would help to elucidate the central theme. In many instances the result was to produce a masterful re-examination of a body of knowledge whose potential for social consequences and policy implications has been overlooked, often by the specialists themselves.

In order to launch discussion, the paper writers were asked to "summarize their summaries" and to allow time for questions and comment. Authors were invited to offer informed speculations about the future evolution of their specialties, and to introduce "policy implications" if they chose.

No participant who exposed himself to the exercises in Part I will forget some of the changes that were made in his own cognitive map. He acquired an updated view of the present state of scientific knowledge that, as always, combined brilliant advances with frustrating gaps and evocative questions.

A comment about the arrangement of the presentations in Part I. The Conference began with the sciences whose concern is with outer space, the atmosphere, the surface, and the subsurface. Next came the biological and medical sciences, followed by the physical sciences and engineering. Finally, the sciences of man and his culture. The discerning observer will notice the latent frame of reference in this selection, which conceived of "man" as a living form seeking to optimize his "values" (preferred outcomes) through "institutions" interacting with the "resource environment." The procedural point may be noted that the actual program sequence alternated the presentation of papers about the physical and biological sciences with papers about the social sciences. The aim was to reduce the temptation to skip sessions "outside my field," which is one of the intellectual devices of self-segregation that the Conference sought to counteract.

Part II of the program emphasized the "double vision" required of Conference members. Besides participating in the sessions of Part I everyone was expected to join a Working Group on the social consequences and policy implications of scientific knowledge. The topics were closely related to the arrangement of the summary papers in Part I. There was, nevertheless, a definite difference in what was expected. The leading question was no longer about specific specialties. The Working Groups dealt with selected sectors of society and environment. Each sector involved a horizontal cut through all fields, since every field must be considered when social consequences and policy implications are at issue. The problems that arise in thinking about "cultivating resources" go beyond the physical setting to the complex interplay of changes in the physical environment with changes in biological and cultural

configurations. "Population, health, and family" strategies must go beyond biology and culture to the assessment of meteorological and other features of the resource environment. A similar observation applies to policies designed to affect world "scientific knowledge, education, and communication," "economic and social strategies," and "decision processes." The latter was of particular relevance to the aims of the Conference, since a major aim was to go beyond the laboratory or the field expedition and to make an impact on policy forming and executing processes. The "working groups" into which the members of the Conference were divided for the purposes of Part II were explicitly interdisciplinary. Each group had the assistance of a legal scholar accustomed to summarize proposals and justifications for the use of decision makers.

Conference procedure enabled the Working Groups to begin work on the second day of the Conference, which was before all the papers prepared for Part I were discussed. A provisional chairman opened each meeting, but each Working Group was authorized to change the chairman, and also to divide into subgroups, if desired. Members changed the Working Group initially chosen if they wished. The reports of each Working Group were presented to the Conference as a whole for discussion on the last two days.

As might be predicted, the Working Groups differed greatly in the speed and ease with which they executed the task assigned to them. As the record shows, the discussions were often vigorous and full of divergences of view. Despite the pressure of time, all the provisional reports were forthcoming; and many of the participants found the unaccustomed role that they were asked to play both thought-provoking and frustrating.

The Conference devoted an evening to the World University proposal of the World Academy. It was a great satisfaction to Dr. Hugo Boyko, ill as he was, to take part in the lively discussion. (To our intense regret Dr. Boyko, who initiated and guided the World Academy of Art and Science, died soon after the close of the Conference.) Dr. Boyko's dream for the World Academy was to bring into existence under the auspices of the Academy a world university of a new kind. Instead of having a supercampus in one place, the institution would reflect pluralism and decentralization. With the assistance of Academy members the conception had been formulated in a basic memorandum that was widely disseminated in university and U.N. circles and helped to give shape to the many initiatives that have created a diversified "world university movement."

The New York Conference was attended by scientists most of whom were willing to impose on themselves the severe discipline required by the program. Only one occasion was open to invited guests. At the Dinner a tribute was paid to the memory of Dr. Chester Carlson, whose benefaction helped the American Division of WAAS to plan and hold the Conference. The Dinner was an occasion for the significant pronouncements on the Conference theme that were made by two eminent Fellows of the World Academy, Dr. Seaborg and Dr. Tiselius.

The concluding note to the present volume will indicate how the work of the Conference is to be continued in the immediate and the more remote future.

International Joint Conference on Environment and Society in Transition

INAUGURATION

Dr. Boris Pregel

Chairman of the Conference

PREGEL: This is the first session of the International Joint Conference on Environment and Society in Transition, organized by the American Geographical Society and the American Division of the World Academy of Art and Science. I declare this Conference now open.

A short time ago, while glancing through Bertrand Russell's book "A History of Western Philosophy," I found the chapter dealing with the birth of science in the 17th century. I was amazed at the apparent similarity to ours of the problems of those remote days and hours. In those eras, we find war and social change as well as a new conception of ethical and cultural values that revolutionized previous patterns of existence; this was even more true in science, where a sudden, incredible progress created new problems that had a tendency to alter the old, narrow concepts of world thinking.

This science of the 17th century drew a world still clinging to the fears and superstitions of the Middle Ages into the age of rational thinking. Today we are witnessing another great scientific revolution, the result of which can only be guessed at now. What, then, does the future hold for us?

Galileo, Kepler, and Newton observed and explained by logical physical laws natural phenomena that, until their time, had been considered coincidental or had been ascribed to supernatural forces. It is easy to realize how deeply the discoveries of these men influenced their contemporaries, and it is just as understandable that they brought forth such rhymes as one quoted by Russell:

"Nature and nature's law laid hid in night/ God said, 'Let Newton be' and all was light."

It does not take a great deal of imagination to adapt this couplet to our times if only we substitute for Newton any one of a variety of present-day scientists and replace the word "light" with "power." It is especially now that we realize how completely dark it is that still surrounds us, although, and perhaps because of the fact that we have harnessed a power that has the potential to decide between our being and not being.

I become frightened at the immensity of the subject. The problem facing humanity today is of a tremendous and complicated nature. Now technology is intimately bound to social, political, and economic questions, and, if I may say so, to the change of the structure of our life and philosophy.

The new era, based on new discoveries, will be different from what we are accustomed to. We would like to define the real place of science in human

society. We can affirm that, since the inception of the world, never have we been so rich in knowledge as we became in the past 40 years, but never was this knowledge used so badly. It seems that mankind, which became capable of transforming the world at such a rapid pace, has ceased to understand exactly what it is doing. It is absolutely clear that science can make accessible to mankind all the food, work, security, and liberty to which it aspires. But along the road to this achievement, mankind faces the danger of death, misery, and unhappiness. There is also the very important problem posed by man's misuse of his environment and his biological potential.

Recognizing the imminent danger facing the world, the Nobel Foundation organized, in September of 1969, a symposium, "The Place of Values in a World of Facts." This conference is the continuation of the discussions initiated in Stockholm. We hope that our international and interdisciplinary discussions will be able to present the intellectual community with a new approach to the solution of world problems.

ELISABETH BOYKO: My husband is unable to be here, and he has asked me to give you a brief message for him, and I will add a few words as a general comment of my own. The World Academy of Art and Science and the World University was founded to study and discuss the means for investigating the problems of mankind and to seek their solutions; nothing can be more vital than those problems, the solutions to which open the way to man's survival.

Looking back, one could be drawn to consider the overall dangers that were recognized about 25 years ago by the founders of the World Academy. One must admit that this recognition of the problems and dangers is now growing with great acceleration in the scientific world and in other groups, as well.

Every one of us is personally deeply engaged in his own scientific work. My own field is that of desert reclamation and the development of an inexpensive but effective purification of waste water, heavily polluted by organic and inorganic waste material. We have reason to believe that we have found a solution for these vital problems, but we must still find a means to close the gap between the scientific results and the practical application.

The same probably applies to many other fields of science, and I am looking forward to this conference and to the working groups where these steps will be discussed. I am convinced that for quite a number of fields the commissions of the World University will find progressive stages of preparation for their work and in some cases even well-prepared steps toward a task force. But in all cases we shall have to obtain material and emotional support from outside. Some of the most important emotional support will have to be from the younger generation. We must show them constructive ways and solutions to the problems, solutions based on the most recent knowledge and know-how. And they must, in turn, recognize the challenge and be willing to contribute their best constructive efforts.

Why are most people now aware that, more and more, global planning has become a must and that global cooperation has to substitute for traditional power politics? During the last 20 years or so, the influence of scientists on political leaders has grown, but even in the best of situations, it is only a secondary, advisory role. In order to obtain the moral and material support of the masses in the fight to stop the approaching world catastrophe, scientists will need the cooperation of those leaders in the political, financial, and spiritual fields who are able and unselfishly willing to bring about the support

and to arouse in the masses the emotion that is necessary to obtain sufficient political support.

It is, therefore, hoped that this conference will, to the highest degree, obtain the cooperation of the world press. Only then, by close cooperation among the leaders in science and technology, and the political, spiritual, and financial leaders, and the world press and the younger generation, can the strategy to solve the problems that face us be found and implemented.

PART I: PLENARY SESSIONS

Space and Earth Sciences

Lloyd L. Motz, *Chairman*

Serge Korff, *Cochairman*

MOTZ: It is quite appropriate that we begin by considering the developments of science today. The title of this meeting, "Environment and Society in Transition," can best be understood if we know first where we are. Each of us in his own discipline does indeed "know" to some extent. Perhaps we have a great deal of knowledge; perhaps we know very much and understand very little. I hope we may concern ourselves with understanding more, and understanding more in terms of all the vast amount of knowledge we have accumulated. Here I would like to go back a few thousand years, to 92 B.C., when Lucretius, the popularizer of the theory of the atom, wrote a remarkable poem, "No Single Thing Abides," in which he points out things that are extremely modern. He *understood* things, but, of course, he did not *know* very much; thus he remarks that the systems in the universe are constantly changing: "I see the suns, I see the systems and their forms and even these, the systems and suns, go back to their eternal drift."

Then he makes a notable remark; he says that every atom in existence was, at one time, part of another star, that we could not be where we are or how we are unless we had passed through something else: "This bowl of milk, the pitch on yonder jar, are strange and far bound travelers coming from afar." And finally Lucretius speaks about science, "this voice that stills the pulls of fear and through the conscience thrills."

This is indeed the situation today: if science cannot show us the direction to peace and a better world, all our knowledge, all our understanding will be useless. It is with this goal in mind that this conference has been called; the following discussions are to be completely open-ended, nobody will be limited to delivering a prepared speech. Our first paper today is from Prof. A. G. W. Cameron; he will be followed immediately by Dr. Serge Korff.

RECENT ADVANCES IN ASTRONOMY AND SPACE SCIENCES

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Introduction

The astronomical sciences have had rather little impact on our day-to-day lives, but from ancient times their philosophical impact has been very great. Primitive man could see that there were many unreachable things in the skies about which he knew nothing; undoubtedly the appearance of the heavens had much to do with the formulation of primitive religions. In recent centuries, as we have learned more and more about the universe and our place in it, man has seemed to occupy an ever-decreasing position of importance in his total universal environment. The skies no longer turn solely about the earth; the other stars no longer turn solely about our sun. The sun has become a normal undistinguished star situated in our galaxy, and our galaxy is but one of billions of similar galaxies strewn throughout space, with no indication that our own position in space has any special significance.

The pace of discovery in astronomy and space science has been particularly hectic during the last decade, and this has led to an intense intellectual ferment in the field. In this article, I will skim quickly over a few of the highlights of the research discoveries that have been made, and at the end I will try to indicate what our present philosophical outlook is toward the universe in general.

The Large-Scale Universe

During the first half of this century, some of the most important developments in astronomy established that spiral nebulae are external galaxies at large distances from our own and demonstrated that there is a correlation between the spectral redshifts of the galaxies and their apparent distance from us. These developments led to the concept of the expanding universe. Modern cosmology has developed from both this observational picture and the underlying theoretical developments of general relativity. For a long time, cosmology has been, basically, a science in search of facts. In the last decade, a number of new facts have been established that have an important bearing on cosmology.

Perhaps the most important of these is the discovery of an isotropic background radiation at microwave frequencies. This radiation appears to be incident on the earth uniformly from all directions, and as far as we have yet been

able to determine, it has a blackbody spectrum characterized by a temperature of 2.7° K. The most commonly accepted interpretation of this radiation is that it is leftover light, emitted during the early expansion stage of the universe, when all matter was tightly compressed and the universe was a very hot place, opaque to electromagnetic radiation. Dicke has graphically described this radiation as the remnant of the flash from the primordial fireball. If this interpretation is correct—and much confirmatory experimentation still must be done—then the background radiation is the most primitive observation that can be made in cosmology; it is the earliest light of any kind that it would be possible to detect. We are, in fact, seeing the early universe in its own emitted light, which has been redshifted to the extreme radio wavelengths.

Less primordial, probably less fundamental, but certainly stranger, are the quasars. These are brilliant points of light frequently shining with an intensity 100 times as great as that of the brightest galaxies. Yet this tremendous energy output is generated and emitted from a region less than a light year in diameter. We do not know if quasars are extreme forms of galaxies, although this may be so, but we suspect that they are beacons shining to us from enormous distances in space and enormous intervals back in time. The spectral lines emitted from the quasars have undergone a redshift of as much as three times the original wavelength, and sometimes a little more. Most astronomers interpret these very large wavelength shifts as indications that the emitting objects lie well beyond the faintest galaxy whose redshift has been measured. For about a decade, theoretical astronomers have been completely puzzled about the detailed structure and operating processes of the quasars. Now a new observational statistical puzzle is emerging: there are many quasars up to a maximum redshift, and, suddenly, beyond that redshift, no more are observed. Will this tell us something important about the ancient history of the universe?

Our Galaxy

Perhaps the most exciting discovery that has been made in recent years about the contents of our own galaxy is the pulsars. These clocks, ticking in the sky, shine bursts of radio waves at us every second or so. About a year after their discovery was announced, the tremendous number of observations made by radio astronomers finally seem to provide strong evidence that the pulsars represent the discovery of an entirely new type of star, with an entirely new type of matter, similar to the nuclei of our atoms. This so-called neutron star is an assemblage consisting mostly of neutrons, but it may also have minor components of protons, electrons, muons, and hyperons, all gathered together within a radius of perhaps 13 kilometers and having a mass similar to that of our own sun. Such objects had been predicted by the theoretical physicists during the 1930s, and a few people had continued to study their theoretical properties since that time, but little attention was paid to such theoretical predictions until the discovery of the pulsars. Perhaps there was good historical reason for this: the neutron star was really the first type of major astronomical object to be predicted by theory before it was discovered.

About ten years ago, the new science of x-ray astronomy was born when a rocket ascended above the atmosphere to look for x-rays from the moon and instead found them emanating from a new type of astronomical object, the Scorpius x-ray source. X-ray astronomy can be accomplished only from above

the atmosphere, because the atmosphere strongly absorbs x-rays; hence, this was one of the earliest important discoveries resulting from space research. Since then, the x-ray sky has been observed repeatedly by rocket flights, and about 50 x-ray sources have been located. Some of these are very variable in time and rise to a maximum intensity and then fade below the level of detectability. There are two basic types of x-ray sources: a source that has rather high-energy x-rays, typified by the Crab Nebula, which may represent supernova remnants; the other type of source is a blue pointlike object—examples of which have been identified with several of the x-ray sources—whose nature is still unknown. The astronomer has come to expect that when a new region of the electromagnetic spectrum is opened to observation for the first time, completely new types of astronomical objects will be discovered. X-ray astronomy has not let him down in this regard.

Much of infrared radiation is screened from the surface of the earth by absorption in the atmosphere; this absorption is mostly due to water-vapor molecules, but there are a few wavelength windows through which the infrared sky can be observed. It can also be observed from the high atmosphere with balloons or aircraft above the bulk of the water vapor.

Infrared astronomy was a little slow in beginning because of the lack of efficient infrared detectors. In recent years, many important advances have improved infrared detector efficiencies, and, as a result, the science of infrared astronomy has begun.

Here, too, there have been important new discoveries. Certain stars, very faint in visible light, are enormously brilliant in the infrared, probably because surrounding clouds of dust particles largely thermalize the radiation emitted from the star. There has also been at least one distinctly new type of infrared object observed: the infrared nebula. Such an object exists in the vicinity of the Orion Nebula; it has a surface temperature of only about 100° K, yet it shines at a rate of about a million times the luminosity of the sun in the far infrared wavelengths. Some astronomers think this may be a location in space where new stars are actively forming.

Some of the most exciting discoveries about our galaxy have been made by the radio astronomers. For years they were rather unhappy that they had only one spectral line to observe, the 21-cm line emitted by neutral hydrogen atoms. Studies with this line were very important for astronomy: they determined the location of large clouds of hydrogen in interstellar space, as well as relative velocities. Now, suddenly, in the last few years, the radio astronomer is deluged with a large number of spectral lines, which started with the discovery of four lines due to OH, the hydroxyl molecule, in interstellar space. The hydroxyl molecule does not behave in a simple fashion; it enhances any or all of its spectral lines in an apparently capricious manner. This enhancement has been attributed to a masering action, stimulated emission resulting from the overpopulation of an excited state of the molecule. One of the truly astonishing accomplishments of the radio astronomers has been the demonstration, with a world-wide radio interferometer, that some of the regions emitting OH lines have dimensions as small as that of the solar system, even though they may exist thousands of light years away from us.

More recently, radio lines due to ammonia (NH_3), water (H_2O), and formaldehyde (CH_2O), have been detected. The ammonia does not appear to have masering action, but the water vapor does. The formaldehyde seems to be a kind of antimaser: it has an overpopulation of the ground state, and, hence, an anomalous absorption of radio radiation at its characteristic wavelength. These observations indicate that the interstellar gases have a strange chemistry of their own that we are only beginning to discover.

Our Solar System

Physicists, during the last decade, have been busy with spacecraft measurements determining the presence of energetic particles and magnetic fields in space. They have determined that our planet is surrounded by a shell of energetic particles trapped in the outer reaches of the magnetic field. Beyond this magnetosphere, interplanetary space is filled with an outrushing plasma from the sun, an expansion of the solar corona, which carries its own imbedded magnetic field. Sometimes interplanetary space is also filled with large numbers of energetic cosmic rays accelerated by solar flares. Thus, an apparently uninteresting part of the solar system has turned out to be full of energetic and dynamic phenomena.

Automatic spacecraft have made a preliminary exploration of the nearby planets. Venus has been found to have an extremely thick atmosphere composed predominantly of carbon dioxide and to have a pressure at the base of about 100 atmospheres. The surface of the planet is enormously hot, about 700°K, and is thermally well shielded from interplanetary space. The atmosphere contains almost no water. Although Venus is a planet with nearly the same mass as the earth and nearly the same radius, its atmosphere is extremely different from that of our own planet. Nevertheless, it seems that the planets are chemically very similar, and many atmospheric physicists believe that the earth would become as Venus is now if it were moved closer to the sun.

Mars also has an atmosphere predominantly composed of carbon dioxide, but this atmosphere has a pressure at the ground of less than one per cent of our own. Indeed, the atmosphere of Mars is in equilibrium with its polar caps, which are also composed of carbon dioxide. The pressure of the carbon dioxide in the Martian atmosphere adjusts itself to equality with the vapor pressure of carbon dioxide over the pole that happens to be experiencing winter at a particular time. There are mere traces of water in the Martian atmosphere, and there is almost zero chance that liquid water can exist on the surface of the planet. Hence it is very unlikely that Mars will prove to be an abode of living beings. Spacecraft pictures of the Martian surface show that it resembles the surface of the moon in many respects, having large numbers of craters. However, the atmosphere makes a difference, and evidently dust on the Martian surface is blown around sufficiently to obliterate the smaller craters in a short period of time.

Probably the most striking results of any of the space programs have been those resulting from the manned exploration of the moon. The Apollo 11 and 12 astronauts brought back many kilograms of lunar rocks and dust that have been subjected to intensive investigations by a wide variety of laboratory techniques. The findings indicate that the moon is largely a chemically differentiated body and that it appears to be deficient in iron as well as in other elements that have relatively low vaporization temperatures for common compounds. In the interior of the moon, where the rocks now on the surface at the Apollo 11 landing site were formed, there was a dramatic absence of water. This resulted in the formation of minerals under very dry and higher

temperature conditions that would occur on the earth, with highly significant differences in the mineral content of the rocks.

These tantalizing first glimpses into the bulk chemistry of another planet will provide extremely important clues to the origin of that body and of the solar system as a whole. The moon is markedly unlike the meteorites, the other sources of extraterrestrial material that have been examined in our laboratories. The moon appears to have formed under high-temperature conditions, with a strong absence of the more volatile elements, whereas the meteorites seem to have formed under much cooler conditions, with retention of most of the more volatile elements. Additional landings on the moon will help to extend this information and to render much more certain our preliminary conclusions about that body.

Man's Place in the Universe

These have been a few prominent examples of the many dramatic advances in astronomy and the space sciences that have occurred during the last decade. But these advances are merely the highlights of a tremendous amount of investigation that has been carried out, of both an observational and a theoretical character. The usual pace of research produces a succession of small discoveries, but the intellectual impact of these mounts as the total number of small discoveries grows. Therefore, in this last section, I shall outline some of the principal philosophical points of view that have emerged about man's place in the universe.

The dominant concept resulting from modern research into star formation and the origin of the solar system is that we must expect planetary systems to be extremely common in space. Many stars, perhaps 80 per cent of them, occur in binary pairs. Some investigators view this as merely another manifestation of the tendency for matter to orbit around stars in space; in this case, the stars orbit around each other. However, theories of the origin of the solar system now tend to place the origin of the planets in the general process by which the sun itself formed. Hence, there may be between 10^{10} and 10^{11} planetary systems in our galaxy.

Biochemists studying problems associated with the origin of life tend to conclude that chemical evolution on the earth followed the chemically-most-likely path in every discernable instance. Thus, if a reaction takes place involving complex organic molecules, which may yield many different products, the most common products are the ones that appear to be incorporated in living beings. Therefore, the chemical and biological evolution that has occurred on the surface of the earth appears to be a natural consequence of a favorable environment. It is generally expected that similar chemical and biological evolution will develop anyplace in the universe where conditions are similarly favorable. This means that we should expect the existence of an immense number of planets in our galaxy on which life has originated and evolved.

Will these theoretically prevalent biological systems generate intelligent beings? Obviously, science is not in nearly as good a position to answer this question as it is to answer questions about the likelihood and prevalence of planets favorable to the origin of life. Nevertheless, the biologists tell us that environmental stresses lead toward evolution, that the old doctrine of the survival of the fittest plays a significant role, and that, because intelligence may allow one species to dominate over all others, it is probably only a matter of time before a biological system with ample natural resources will develop intelligent species.

A further question is whether an intelligent species will develop a technology. This may depend on the evolution of a suitable manipulative organ in the intelligent species. On the earth, it appears that the possession of a readily manipulative organ, the hand, played a significant role in the development of intelligence in human beings, and this may also be a general phenomenon. It is a logical consequence of the entire trend in modern interdisciplinary thinking about the prevalence of life and intelligence in the remainder of the galaxy that we should expect enormous numbers of intelligent civilizations to have developed in the vicinity of other stars.

The basic technical requirements for interstellar signaling already exist. The large radio antenna at Arecibo, Puerto Rico, is capable of sending signals to a similar antenna located many hundreds of light years away. It is quite within our technical capabilities to construct even more sensitive antennas capable of communicating across still vaster distances.

Nobody has yet done much listening for extraterrestrial civilizations. But someday, logic tells us, we should find such signals coming from interstellar space. When this happens, astronomy will not be just a science of the immense void that helps shape our philosophy and generate intellectual ferment, but will also help generate some of the most important social consequences that the human race is ever likely to encounter.

A PHYSICIST LOOKS AT GEOGRAPHICAL AND ENVIRONMENTAL PROBLEMS

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Introduction

In the last few years, and most especially, very recently, a trend has emerged that seems most desirable from many points of view. This is an increased concern with the quality of our environment. Recently, undergraduates, senators and congressmen, and a wide variety of other persons have all evinced a growing interest and awareness. That this concern is justified admits of no debate. Quite clearly, mankind has managed to spoil so many and such conspicuously large portions of his environment that the problem has reached a crisis stage in many fields. There are, however, some cautionary points to be considered; and I hope that something may be generated that will be a net benefit and will not, because of ill-considered, hasty action, create more problems than it solves.

Trends Already Discernible in the Movement

In the United States we have a great fondness for simple solutions for complicated problems. We love to say, "All you have to do is . . .," and imply that thereby the solution is at hand and the troubles are over. There are all too many illustrations of this characteristic approach. For example, although excessive alcoholism clearly is an evil, the simple solution of making it unlawful drew our country into a situation from which we may not have recovered yet. In the days when we imagined we had only one potential enemy, we promulgated a foreign policy of deterrence based on "massive retaliation." This policy has also led to consequences that plague us long after the policy itself has been abandoned. In the environmental sciences, it is often easy to say, "Oh, we must not do so-and-so," thereby avoiding one set of problems but firmly pushing ourselves into another set.

Another characteristic, which I am afraid will soon manifest itself in the environmental field, is our mercurial tendency to lose interest in an effort, especially after an initial victory has been won. We do not like to stick to a problem, especially when the going gets difficult. Again, all too many illustrations come to mind of the effects of this national characteristic. We are soon going to run into cases in the environmental field where this effect may plague us.

Still another facet of our present operational procedure is that the entire conservation movement has built-in overtones of being against everything. Time and again in the last few years, I have received letters from conservation groups asking me if the organization I represent, or sometimes if I, personally, will not join in an effort to halt something. Perhaps, indeed, the something

needs halting. Yet it is astonishingly seldom that any appeal comes to get something positive done; it is always to oppose what someone else wants to do. This posture of opposition to every proposal is not one that bodes well for our future development or for our growth possibilities as a nation or as a world.

It seems to me that we must be positive rather than negative with respect to our manifold problems. The problem is to consider the best way to accomplish something, to consider what the long-term problems are that a given procedure may generate, and then to choose the route that will generate the fewest problems. We will not find solutions that generate no effects. What we must decide is what price is acceptable.

The Basic Choices of Mutual Opposites

A basic reason for our many really difficult problems is the fact that there are two, and often more, mutually exclusive and opposite desiderata. We have thus far been unwilling to take seriously the measures that will limit a rapidly expanding population. We all know what these measures are and we know that technically the job can be done. But politically we have been unwilling to do it. This rapidly expanding population will require increased production of food, of goods, and of services. It will require much more electrical energy. We will have to build many new power plants. The population will want to ride around in cars and will need roads to ride on, while the cars pour out noxious gases. We cannot have it both ways.

If we wish to conserve our environment, it can be done. If we want to limit our population, this too can be done. But the hard fact is: we cannot, at the same time, refuse to limit our population growth and also stop building new automobiles or power plants or extracting more oil or cutting down more forests to build houses for this growing population to use.

It is regrettable that all this is so. A given policy has certain consequences, and they are quite predictable and inescapable. As a nation or as a world, we cannot institute the policy and refuse to accept the consequences. If we have more people, we will do more damage to nature. If Masai tribesmen overrun the African game reserves with their expanding cattle herds, we shall have fewer big animals. If we feel we must feed the world's starving millions, we must put more land into agriculture and use more fertilizer.

Some Specifics

Another one of our great problems arises out of our desire to have certain benefits without paying for them. An excellent illustration of this is the situation in power generation. It is quite clear that we shall have to build new power stations, not only to provide power for the expanding population but also just to take care of the increased demand imposed by the existing groups, which all demand more each year. We want these power stations to be inconspicuous and not to pollute the environment. And yet, what do we do? Some years ago a nuclear plant was suggested for the New York area, but political pressure forced its abandonment. To supply the needed power, the utility companies have had to expand their older steam stations, which are

notoriously polluting. Let us take a good look at the problems of power generation.

A steam plant, burning fossil fuels, generates ash and carbon dioxide, the products of combustion. The carbon dioxide is invisible, but who can maintain that the literally millions of tons we are spewing forth do not produce undesirable effects? The effect on the atmosphere's heat retentivity is too well known to need further review. The second type of pollution generated by steam plants is thermal. The condensers must be cooled. This process requires a lot of water, which, in turn, becomes heated and warms the nearby streams when it is discharged. Although a nuclear plant does not produce carbon dioxide, it also generates two problems: one is the disposal of radioactive wastes and the other is, again, thermal pollution.

Much of the pollution can be abated or minimized if we are willing to pay for it. The objection "That would be uneconomic" is the key issue. If we want to keep smoke under control we can do it. We can install smoke precipitators; they cost money. We can recirculate condenser-cooling water; such recirculation also costs more than does the alternative of taking nice, clear, cold water from our reservoirs and discharging it after it is heated. It is possible by chemical treatment to reduce the bulk of nuclear wastes, to concentrate them, and to prepare them for storage for a time long enough for the induced radioactivity to decay. But this costs money. As long as our public service commissions, which fix rates, are busy thinking only of what must be done to keep the rates down, they will not permit the generating companies to charge what is needed to do a really effective job on pollution abatement. We must realize that we have the technical skills *now* to generate vast amounts of power with minimal accompanying pollution, but we have programmed our regulatory agencies not to permit this. If we are sincere about not wanting pollution, we must pay the costs.

Many other illustrations come to mind. Automobiles can be built that will generate less of the fumes that give rise to smog. But the additional devices cost money and many persons are unwilling to face these added costs. Changes in the engines of transport aircraft can greatly reduce the smoke plumes. But in the long run the cost of such changes will show up in higher fares, which many persons and regulatory commissions resist. It is quite clear to anyone who has been stacked up over New York City in an airplane that New York badly needs another major airport. But the chief objection to any proposed location has come from the conservation groups. For some years now, any new airport proposal has been blocked. This hardly seems a good long-range solution. Access to all New York metropolitan airports is by automobile only. Certainly we could prevent the emission of vast amounts of exhaust fumes by constructing subway extensions to the airports from our existing subway system.

Conclusions

We will continue to have problems as long as we continue to insist on following mutually antagonistic policies. Our problem is not a technical one. We know how to do most of what we need to do without generating unacceptable amounts of pollution. But we are quite unwilling to pay the necessary costs, be they in money or in political policies. Science and the technology stand ready to do what needs to be done. If we are sincere in our protestations concerning our environment, we must not just say "no" to every new proposal. We must, on the other hand, consider how the techniques can be implemented, and if this requires paying more in order to pollute less, we must be willing to pay. If we are unwilling to limit the population explosion, we must face the fact that there will be more people damaging our environment, and more industries to serve those people tomorrow. If we insist on electric power and industrial output as cheap as possible, we will find that these same industries produce more wastes. What we need to do is to apply our knowledge, with the desired end in view, and with the further stricture that if the end we desire is not the most economic one, we are willing to pay for the differences. With such an approach we can still make progress. At the moment I do not see any acceptable alternative.

* * *

MOTZ: I should like to address myself to another aspect of the problem of saturation. It appears that the problem facing us is, essentially, saturation of population, of contaminants in the atmosphere; I should like to propose that possibly we are also reaching an intellectual saturation, that is, the striving of people toward new intellectual ideas seems to be reaching a kind of leveling off, and it is difficult to see where new things are going to come from. And I particularly should like to consider the problem of physics.

If we look at the laws of physics, we discover that the modern period is governed by two great theories, the theory of relativity and the quantum theory, and these have proved adequate to explain many things. As an example, I might indicate the development of stars. Today we know pretty well how stars evolve, how they develop, and this, in a sense, has given us a solution to the important problems that were presented to scientists, astronomers particularly, at the beginning of this century. We know now that a star is a natural concomitant of the evolution of the universe itself. It is part of an overall cosmological problem, and if we apply the laws of relativity and quantum mechanics, we can understand quite well what goes on.

We know today that the atoms all around us, the atoms in our solar system, evolved or were formed through the evolution of stars, through the evolution of certain types of stars—the older stars, which then, in some manner or other, expelled vast quantities of material, and from this material solar systems like ours were formed.

We can also investigate various other problems, such as those presented by Dr. Cameron, and in each case we apply the two theories that we understand, the theory of relativity and the quantum mechanics.

Is it possible that we have, in a sense, come to the end of the formulation of new, great theories? I know this is a shocking idea; many people in scientific research will argue that if such is the case, it is hardly worth living.

But let us examine the situation. These two theories, the theory of relativity and the quantum theory, which in a sense introduced two very basic constants, the speed of light and the quantum of action, were developed at about the same time: in 1900 the quantum theory was introduced, and in 1905 the theory of relativity.

Then there was a period of tremendous activity with the discovery of what we call the quantum mechanics, that part in nature of wave characteristics. In the period from 1900 to 1925, during which all of this developed—a kind of golden age of physics—we find two basic principles were discovered, the basic principle that is the theory of relativity and the basic principle that led to the quantum mechanics, the notion of a quantum of action. From 1925 to the present, some 45 years, with the greatest concentration of scientific minds

working in this area, there has been no basic discovery, no new discovery or development of a basic theory. Even such developments as the laser and the discovery of antiparticles, the positron, all stem from the basic theories. We would not dream of trying to understand these new technological discoveries in terms of theories other than the theory of relativity and quantum mechanics. The laser, for example, which is a representation of one of the most advanced technological developments, was discussed in a paper by Einstein in 1917. It is not a new basic principle. The pulsars, which are important discoveries in astronomy and are, indeed, newly observed, must be understood in terms of relativity and quantum mechanics.

Consider the discovery of antiparticles: the positron was discovered in 1934 by Carl Anderson, but the positron as anticlectron was predicted in 1928 by Dirac on the theory of relativity and quantum mechanics. This was a purely mathematical extension of the theory of relativity.

Because we now find that the rate of discovery of basic principles has been practically nil since 1925, we must ask ourselves where is science to go? In what direction is science to proceed? It is true we shall discover many, many more facts, we shall discover many new technologies, but will we have new theories to work on? Will the excitement of science be the same in the future as it was from 1900 to 1925, as least in the physical sciences? When it is argued that there is a great deal to discover, I must answer that indeed there is: facts. Let us consider, for example, the field of particle physics, which is a kind of force that is not at all understood. Vast numbers of facts. But again, they must be treated within the realm of the two basic theories.

It is true that new mathematical techniques are introduced, new approaches and new skills are developed, but there is no departure from the basic theories. Therefore, the question I wish to propose, and that I hope may stimulate some discussion is this: Are there new basic theories to be discovered or are we simply looking for new forces? It is true that whenever we find a new force, when we go from a study of the structure of the atom itself—the electron circling the nucleus—to the nucleus, we run into new forces. We speak of nuclear forces, but we study the nucleus again in terms of quantum mechanics and relativity theory.

This is a topic worth considering because we find more and more young people turning away from science. Here I am limiting myself to the physical sciences; I think there is still excitement in the biological and life sciences, but in the physical sciences these excitements have perhaps disappeared or, at least, do not present the same kind of challenge as they did to men like Einstein.

There appears to be a kind of saturation, and if this is indeed the case, then perhaps our approach to the education of youngsters—what we tell them about the intellectual rewards science has to offer—ought to change. We ought not to hold out promises of the same kind that were promised the earlier explorer in this field, and ought perhaps to indicate that science today, at least in the physical sciences, is a matter of very hard, tough work with no great brilliant ideas that will burst upon a person all at once.

If we are going to talk about environment and the relationship of science to environment, I think we ought also to talk about the intellectual environment and consider whether science can offer, or scientific training and learning can offer, the same excitement to young people today as it did in the past.

The next speaker is Dr. Richard Porter.

THE BIG VIEW

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Astronomy is the most ancient of the sciences. Beginning, perhaps, with a sense of awe and wonder at the regular movement of the life-giving sun, the beautiful moon and the stars across the heavens, and the terror induced by an occasional eclipse, it progressed in the minds of the more curious and intelligent to a study of these motions and eventually an ability to predict them with some degree of accuracy. Because of the significance of these celestial objects in early religions, this primitive scientific knowledge was carefully accumulated and passed on at first by word of mouth and then in written records within the priestly hierarchy. There was much nonsense, of course, from our 20th century viewpoint, but the essence of science was there: observation, accumulation, and categorization of information; attempt at rational explanation, prediction, and application.

It would appear that the beginnings of astronomy were probably in the cradle of civilization, Mesopotamia, begun perhaps by the Sumerians and continued even more strongly by the Babylonians, spreading gradually into China, India, and Egypt. The noted astronomer Fred Hoyle[a] suggests that in Mesopotamia the work was largely numerical and empirical, perhaps a kind of code-cracking exercise. Meanwhile, a parallel development occurred in early Greece, where the subject was of more philosophical than religious value, and it seems that the Greeks were the first to try to think of astronomical problems in terms of geometrical models. That these early scientific studies had practical significance can hardly be doubted. Architects laid out temples and tombs precisely in accordance with celestial references; navigators steered their primitive ships over the open seas using only the sun, moon, and stars to guide them; farmers timed the seasonal planting and harvesting of crops by observed positions of the heavenly bodies.

Various technological developments, in particular the invention of accurate clocks and chronometers, the telescope, the photographic plate, the spectrograph, the sensitive photometer and photoamplifier, have greatly extended and refined the kind of observations that can be made; the burgeoning field of radio astronomy has added a second spectral "window" through which to look at the universe; and space technology has eliminated completely the observational limitations imposed by the earth's atmosphere and made possible the new fields of ultraviolet and x-ray astronomy. Furthermore, the development of even more sophisticated mathematical systems, the availability of powerful computational aids, and the many significant inputs from physical and chemical laboratory experiments have contributed a basis for understanding the observational results of modern astronomy and extending the underlying and unifying theoretical structure that makes astronomy a science.

As in all branches of science, the pace has been accelerating rapidly in recent years. It seems as if each scientific question answered gives rise to

[a] Fred Hoyle, *Astronomy*, MIT Press, 1964.

several new and generally more difficult questions, and each new advance in observational capability opens whole new areas of scientific controversy. Not surprisingly, there has been considerable splintering or specialization within the overall science of astronomy. The International Astronomical Union now has a total of 38 different commissions. However, it might be possible to speak informally about three divisions by type of object to be studied, such as solar astronomy, lunar and planetary astronomy, and stellar and galactic astronomy; and of four divisions according to technique, for instance, optical and infrared astronomy, radio and radar astronomy, high-energy (ultraviolet, x-ray, and energetic particles) astronomy, and celestial mechanics.

Solar astronomy is of direct importance in studies of the terrestrial environment, because the sun supplies all the energy that makes life possible on earth and seems to influence many commonplace phenomena in ways that are not yet well understood. Each of the four technique areas is concerned with and contributes to solar astronomy. Because it is the nearest star, the sun is also of profound interest to stellar astronomers, and as the progenitor of the solar system, it is important in the study of the moon and planets.

The brightness of sunlight, as we see it here on earth with eyes that are sensitive only to wavelengths from about 0.3 to about 0.8 micrometers, is relatively constant, with a small seasonal variation caused by the ellipticity of the earth's orbit and an irregular variation that seldom exceeds ±2 per cent. However, in the ultraviolet and x-ray regions of the spectrum, the radiation we receive from the sun is highly variable. During an intense solar flare, the brightness of the sun increases by as much as 100 per cent in the ultraviolet and by an order of magnitude in the "hard" x-ray region. The flare also produces several distinctive kinds of radio noise bursts and, sometimes, high-energy protons (solar cosmic rays) in sufficient quantity to be a potential radiation hazard to space travelers. There is always some evaporation and escape of less energetic electrons and protons from the very hot (about 1,000,000,000° K) solar corona and these charged particles flow more or less radially outward from the sun, constituting what is generally called the solar wind. When a flare occurs, strong pulses of very hot plasma are ejected through the corona and travel outward through the solar system at a higher speed than the normal solar wind velocity, creating magnetohydrodynamic shock waves of vast proportions. It is the interaction of these shock waves and the plasma concentrations behind them with the earth's magnetosphere that is primarily responsible for the phenomenon known as a magnetic storm.

It would be highly desirable, for many reasons, to be able to forecast these solar-flare events reliably, and therefore much attention is being given to developing the kind of scientific understanding that would make such forecasting possible. It is now well known that the flare is associated with a complex magnetic field configuration surrounding groups of sunspots on the surface of the sun. One major accomplishment of modern solar astronomy has been the development of a capability to measure magnetic fields on the surface of the sun with good resolution both in geometry and in time from telescopes on earth.

Our knowledge of the high-energy electromagnetic radiation and particles emitted by the sun is largely dependent on measurements from artificial earth satellites and deep spacecraft. The Orbiting Solar Observatory satellites, of which six have been successfully launched by NASA, must certainly be considered as a major new observational capability for solar astronomy. An unmanned spacecraft called HELIOS, to be built in Germany and launched by the United States during the mid-'70s, will carry 10 or 11 rather sophisticated experiments to within 0.3 AU (approximately 30,000,000,000 miles) of the sun. The improved detail with which specific areas of the sun can be observed and photographed above the turbulence of the earth's atmosphere and the importance of making observations at wavelengths that do not penetrate the atmosphere have led to the design of a solar telescope to be carried and operated on the first manned orbital workshop of the Apollo Applications Program.

Lunar and planetary astronomy had become an almost deserted field until rather recently. Improved optical telescopes were, of course, being designed, like the 200-inch Hale telescope at our Mt. Palomar, but these big new telescopes were important primarily for their increased light-gathering capability and their consequent ability to "see' farther out into the remote regions of the universe. The ability to make clear, high-resolution photographic images of objects like the moon and planets from the surface of the earth is limited by atmospheric turbulence to such an extent that telescopes of larger diameter than 30 to 60 inches are not useful. In fact, some of the best lunar photographs prior to the space age were made with the 36-inch refractor at the Lick Observatory. Consequently, when most of the details that could be seen through a terrestrial telescope had been mapped for the moon and Mars and the orbits of these and other visible objects in the solar system had been determined with reasonable precision, many astronomers lost interest and moved on to other fields.

It is perhaps interesting to note, as an aside, that during the first half of the 18th century, astronomers were eagerly seeking ways to solve the longitude-determination problem of celestial navigation, which is essentially one of an accurate determination of universal time on a ship at sea. Almost a hundred years earlier, Galileo had thought about using the moons of Jupiter for this purpose, but the idea had proved to be unfeasible. Newton had a simpler idea: the observation of our own moon against the background of the stars. However, it was not until Tobias Mayer, with the aid of Euler's new mathematical techniques, carried out the calculations necessary to predict the apparent motion of the moon, hour by hour, and the first British Astronomer Royal, John Flamsteed, had determined the positions of nearly 3,000 stars to within an accuracy of 10 seconds of arc, that this idea became practical. Oddly enough, it was just about this time that the inventor John Harrison produced a chronometer not regulated by a pendulum, which proved itself capable of keeping accurate time over long periods at sea. It turned out to be at least as accurate for most purposes as navigation by the moon and was considerably easier to use.

In recent years, with the advent of infrared, radio, and radar astronomical techniques and the urgent need to know as much as possible about the moon and planets in preparation for space missions, there has been a reawakening of interest in these bodies by astronomers. It is, indeed, remarkable how much can be learned about a planet by looking at it from earth in all available regions of the spectrum. Radio, radar, and infrared mapping of the moon have provided the gross thermal and electrical characteristics of the lunar surface to a depth of at least several meters, and even though these data can now be obtained at a few points by spacecraft that land on the moon, the astronomical data continue to be a valuable source of information about large-

scale inhomogeneities in subsurface properties. Laser retroflective measurements from earth using the optical corner reflectors placed on the moon by Apollo missions are increasing by several orders of magnitude the accuracy with which one can measure the moon's orbit and motion around its own center of gravity. A precision of ±30 centimeters has already been achieved, and improvement to better than ±15 centimeters seems probable. Measurements of this kind are useful in trying to unlock some of the secrets of gravity, and may also be valuable in obtaining a better understanding of the way in which the continents seem to be drifting over the face of the earth.

Modern astronomical observations of Venus have shown that this planet is, to say the least, peculiar. Almost a twin of the earth in diameter and mass, it is perpetually shrouded in clouds and its surface is extremely hot, on the order of 600° K (620° F). It has a very dense atmosphere (about 60 times more dense than that of the earth), which consists almost entirely of carbon dioxide. It is now known by radar measurements that Venus rotates very slowly in the "wrong" direction, compared with earth, Mars, and the other planets, and that its rotation is synchronized with its own and the earth's orbital periodicity around the sun, so that it always shows the same face toward earth when the two planets are close together. It is also known that some areas on Venus are relatively more reflective than others at radio frequencies, and by a method known as the Doppler-delay technique it has been possible to construct a crude map of the radar reflectivity of the "near side" of the planet. Previous astronomical information has generally been confirmed and extended by the successful U.S.A. and Soviet spacecraft missions to Venus.

Mars also has been extensively studied by astronomers and, more recently, at close range by unmanned scientific spacecraft of the U.S.A. Its atmosphere is surprisingly thin, just as that of Venus is surprisingly thick, and it has no significant cloud cover. Furthermore, the side facing the earth at nearest approach is fully sunlit; because the planet rotates at about the same speed as the earth, its entire surface is readily available to all the techniques of optical, as well as radio and radar, astronomy. Much has been learned by these techniques, including a great deal about atmospheric composition, temperature, wind velocities, and surface material. However, the image resolution of the best terrestrial optical telescopes is not quite good enough to show what the surface looks like. Consequently, it was something of a surprise to everyone when the first crude telemetered pictures from Mariner IV showed Mars to be heavily cratered, much more like the moon than the earth. Both the astronomical observations from earth and the Mariner results agree that there can be no liquid water on the surface of Mars, except perhaps in the form of highly saline solutions deep in crevasses or otherwise protected in such a way as to form a local "microclimate." Furthermore, it appears from the limited available pictorial evidence that there may never have been extensive oceans, lakes, or rivers on Mars, at least during the last billion years or so. Some scientists are, therefore, tending to lose hope that Mars may contain or ever have contained indigenous living organisms, similar to but having evolved separately from those on earth. Because other conditions all seem so favorable, however, it would seem important to carry out a careful study of the extent to which indigenous chemical and biological evolution may have taken place on Mars and, to this end, to avoid contamination of the planet by living organisms from earth or by large quantities of easily dispersible terrestrial organic materials until after such a study has been completed.

Most interesting from the viewpoint of planetary astronomy at present is Jupiter, the largest planet of all. More than 11 times bigger in diameter than earth, and 300 times heavier, Jupiter contains more than twice as much matter as all of the other planets together, yet its density is remarkably low, only about one and one-third greater than that of water, or less than one-quarter the average density of the earth. It spins around its axis in less than 10 hours, faster than any other planet, and it has 12 known moons, one of which is as large as the planet Mercury. It is almost certainly composed mostly of hydrogen, with some helium, ammonia, methane, and enough iron, silicon, and other heavy elements to make a central core about the size of the earth. At the very high pressures existing deep within Jupiter, it seems likely that hydrogen can take on a form more dense than ordinary "frozen" hydrogen, in which the electrons would not be bound to the nuclei but would be free to move through the solid material, as in a metal. Thus, this form of hydrogen would be a good conductor of electricity and heat, and if it does comprise a significant part of the central body of Jupiter, it might explain some of the interesting electric and magnetic properties of this giant planet.

Infrared measurements at different wavelengths indicate that Jupiter is intrinsically warm, i.e., that it radiates more energy than it receives from the sun. Radio measurements at centimeter wavelengths give additional thermal information, presumably at greater depth in the atmosphere. At decimeter wavelengths, Jupiter produces strong synchrotron radiation, from which it can be determined that the planet has a strong magnetic field, tilted about 10° from the rotation axis, and that it is surrounded by belts of trapped radiation. At longer wavelengths, Jupiter emits incredibly powerful bursts of radio energy that last from a few thousandths of a second to several seconds and follow one another in rapid succession during Jovian radio storms. These waves are now believed to be generated by the "dumping" of energetic particles from the magnetosphere into the atmosphere. Exactly what triggers this dumping process is not well understood, although the phenomenon must be similar to that which causes brilliant auroral displays on earth. The radio storms on Jupiter appear to be correlated in some way with the position of the planet's nearest big satellite, Io. Presumably, this satellite, or its magnetic wake, disturbs the Jovian magnetosphere in such a way as to enhance the dumping process.

Jupiter's heavily clouded atmosphere perpetually rages with storms, undoubtedly producing snow and hail of frozen ammonia, perhaps at a lower level even water droplets and ice, and almost certainly violent electrical discharges. It contains all the ingredients thought to be necessary for chemical and biological evolution, except perhaps the placid shallow seas of earth. Whether, in fact, Jupiter even has a true surface, or whether there is just a gradual transition from atmosphere to frothy liquid to solid, is still a matter of scientific conjecture. If life has developed "on" Jupiter, it seems likely that it would have taken a form capable of floating at some appropriate level in the dense atmosphere. The most unusual atmospheric feature is the Great Red Spot, a giant oval about 30,000 miles long and 8,000 miles wide, which has been observed for at least 100 years. It always remains in the southern tropical zone, although it seems to drift about slowly within the zone, and changes color from bright red to dull gray on an irregular basis. Most scientists now believe that it is a large-scale atmospheric phenomenon associated in some way with a topographic irregularity deep within the planet.

Saturn, with its beautiful and distinctive rings, Uranus, Neptune, little

Pluto, the thousands of asteroids, the comets, and the interplanetary dust that pervades our solar system, all seem to hold secrets that can now be discovered by modern astronomy and space research and that will help us to understand how and why we happen to be here, whether or not we are alone, and what our ultimate fate may be.

But most scientists who call themselves astronomers look farther out and concern themselves with the birth and death of stars, with galaxies, the interstellar medium, and the nature of the universe itself. Until about 30 or 40 years ago, because astronomical observations were restricted to the small part of the electromagnetic spectrum that could penetrate the atmosphere on a clear night and be recorded on photographic film, a large part of astronomical research was devoted to collecting data that could not be well understood. Very hot or very cold objects or those that emitted their radiation by nonthermal processes were generally beyond adequate comprehension because so many important data were lacking. Then, one by one, the other regions of the spectrum were opened up. Cosmic rays provided some clues to high-energy processes in the universe. Karl Jansky's observations of radio waves from the Milky Way, although of little apparent interest to astronomers at first, eventually led the way to the giant radio-telescopes that have revealed both high-energy and nonthermal phenomena on a grand scale. Finally, the availability of high-altitude balloons, aircraft, and space technology has opened up the far infrared, ultraviolet, x-ray, and gamma-ray portions of the spectrum. It is now possible to devise and carry out observations to test almost any hypothesis in astrophysics. Perhaps it is why both astronomers and physicists are beginning to regard astrophysics as one of the most interesting and exciting branches of physics.

Among the most interesting subjects of modern astronomy, surely the following must be listed: [b]

1—The strange properties of quasars and Seyfert Galaxies, which appear to involve some of the most energetic processes known, and which may be the oldest and most distant objects ever recognized by man.

2—The mysterious pulsars, which emit powerful radio pulses, so accurately timed that at first radio astronomers thought they must be receiving signals from a distant civilization.

3—The possibility that dust clouds surrounding some stars may indicate the process of formation of systems of planets like our own.

4—The observation of intense maser beams of hydroxyl (OH) radiation from interstellar space, brighter than could possibly be produced by any normal thermal source, even with a temperature of trillions of degrees.

5—The discovery of radiations indicating the presence of water, ammonia, and organic molecules in cold interstellar space, which suggests that perhaps the simplest steps of chemical and biological evolution did not occur only after the earth was formed but were part of the same process that formed the stars.

6—The million-degree temperatures in the solar corona, surrounding the much cooler surface of the sun, when every schoolboy knows that heat flows from hot to cold places and not the other way around!

7—The microwave background of space; is it the reverberation of a primordial Big Bang?

[b] These are adapted from "A Long-Range Program in Space Astronomy," Astronomy Missions Board, NASA, 1969, NASA SP-213.

In its position paper of July, 1969, the NASA Astronomy Missions Board points to the Crab Nebula as a subject for study by all the disciplines of astronomy. This remarkable object, known to be the remnant of a supernova "explosion" that occurred, appropriately enough, on the Fourth of July in 1054 A. D., presumably represents the termination of the life of a star—with a bang, not a whimper. It is believed that, as a star begins to run out of nuclear fuel, its own gravity causes it first to collapse rapidly, then to explode violently, releasing more energy during one year than it had given off in its entire previous life. Theorists have predicted that the residue might include a neutron star—a star so compressed that its atoms would lose their individuality and become, in effect, continuous nuclear matter. Such a star would be only 10 km or so in diameter, but each cubic centimeter would weigh a billion tons or more.

When looking at the Crab Nebula, optical astronomers see a faintly glowing nebulosity, interlaced by a network of delicate reddish filaments that are expanding at 1,000 km/sec. In the center is a faint star, unlike any known stellar types. The light from the nebulosity is strongly polarized, and when this information is combined with that resulting from the strong radiation seen by radio astronomers, it becomes evident that the nebulosity is not just a glowing hot mass of gas but a plasma containing electrons with energy exceeding 100 billion electron volts (velocities near the speed of light), permeated by a relatively weak magnetic field that extends over a region light-years in extent. With the advent of space technology, it became known that the Crab was also a potent emitter of x-ray energy. And only a year after the discovery of the first pulsar, it was discovered that the peculiar star within the Crab Nebula was indeed a pulsar, flashing 30 times a second—much faster than the typical pulsar—in the visible and x-ray portions as well as in the radio part of the spectrum. The total rate of energy radiation by the Crab Pulsar appears to be more than 100 times that of our Sun.

The x-ray, radio, and optical observations all support the model of the Crab Nebula as being energized by a rotating neutron star, rotating at 30 times per second, which resulted from the collapse of the original star and conservation of its angular momentum. The collapse also would have compressed the normal magnetic field previously present in the star to a value on the order of a trillion gauss. According to the model, the electric field induced by this rapidly rotating magnetic field would accelerate particles that would drag the magnetic field with them, emitting synchrotron radiation as they go. This process would extract energy and angular momentum from the star at a calculable rate, which seems to agree with the recent observation that the Crab Pulsar period is slowly increasing.

It will be of great interest to learn whether all supernovae produce a pulsar or neutron star to mark the final stage of stellar evolution or whether some may involve, as has been postulated, an even more fantastic collapse, resulting in a lump of matter so highly condensed that no radiation of any kind, and hence no information, can escape its gravitational pull. Such a gravitational singularity would indeed be a black hole in the universe—into which things and information could enter, but from which nothing would ever return.

Just as it seems impossible today to discuss astronomy without mentioning the contributions of space technology to this venerable science, so it may soon be in other scientific areas. We have learned much about geodesy by carefully measuring the small perturbations in the orbits of artificial earth satellites and about geology from large-scale photographs and images at various wavelengths of the earth from satellites. Physical, chemical, and mineralogical studies of

material returned from the moon are already providing a wealth of new information about our satellite, and it is not hard to predict that they will ultimately tell us something worthwhile about the earth, too. Less than 15 years ago, our understanding of magnetic storms and aurorae on earth was essentially limited to the fact that they were in some way related to disturbances on the sun. Now, because of what has been learned by means of instruments on satellites and space probes, we have a working knowledge of the earth's upper atmosphere and magnetic environment and can intelligently construct and test hypothetical models of solar-terrestrial interaction. We even begin, now, to have some ability to predict what will happen to living organisms when they are transplanted into a space environment.

Trivial as it may seem, after talk of planets, stars, and galaxies, the ability to observe the weather quantitatively at hundreds of thousands of points each day and to track thousands of balloons and recover data from hundreds of ocean buoys may be the key that will enable meteorological science to develop a practical capability to forecast accurately terrestrial weather for as long as two weeks in advance. Some of the same techniques will also be much in demand for tracking the migration of animals, including some sea-going species, and even of large birds.

As the use of space technology matures, I think we shall not speak so much of space science. After all, space is not a science, but a place, even if a rather big place. Instead we shall include space research, that is, research accomplished with the help of space technology, as a part of astronomy, physics, chemistry, geology, geodesy, biology, and so on. In considering the consequences of astronomy and space research for mankind, we are therefore really asking about the consequences of science as a whole, for astronomy is one of the purest of the sciences, and space research is a part of many sciences.

"The pursuit of science," according to Prof. I. I. Rabi, "satisfies a basic desire or aspiration just to know, to find out, or perhaps make order out of the otherwise chaotic jumble of immediate experience. It is an aspiration shared with all mankind, but more with youth and childhood than with adults."[c] Members of the scientific community, continues Professor Rabi, "possess an inner solidity which comes from a sense of achievement and an inner conviction that the advance of science is important and worthy of their greatest effort. This solidity comes in a context of fierce competition, strongly held conviction, and differing assessments as to the value of one achievement or another. Over and above all this too human confusion is the assurance that with further study will come order and beauty and a deeper understanding."

There is little question but that the joy of the pursuit and the quiet exultation that is felt when something new and exciting is revealed are reason enough for a scientist to be a scientist, for an astronomer to be an astronomer. Is it reason enough, however, to ask for public support of science, especially when the tools of science are becoming exceedingly expensive, and when many important and diverse claims are being made on the public purse? It is necessary to examine the consequences of science for society as a whole and to ask how big a price tag can be considered reasonable.

There are, of course, the practical consequences. It is surely no accident that down through the course of history the societies that made their mark

[c] I. I. Rabi, "Science and the Satisfaction of Human Aspirations," Proc. National Academy of Sciences, December 1963.

were those that encouraged scientific activity. In one particular instance, history provides a clear picture of the way in which a nation, suddenly emerging, was able to expand vigorously into the upper ranks of the developed nations. The example is Japan, which just 100 years ago, broke with its own centuries-old tradition of isolation and invited the introduction of science, along with other aspects of Western civilization. After an incubation period of 10 or 15 years, while foreign scientists were imported and a first generation of Japanese scientists was trained, scientific activity in Japan took off exponentially, at a doubling period of about 10 years. The results in terms of industrial development, international trade, standard of living, and original technological achievement are well known. Japan now ranks third in the industrial world, being exceeded only by the U.S.A. and the U.S.S.R., and is the fourth nation to have developed and orbited an artificial earth satellite, using only its own financial and technological resources. Had it chosen to ignore science and import only technology, it does not seem likely that Japan would yet, if ever, have broken out of the status of a clever copier of Western products.

It is rarely possible to trace the individual progress of ideas from the first scientific revelation to the final useful product. However, consider the tremendous consequences that followed when astronomers asked themselves what is the source of energy of the stars, and set to work to find out. Perhaps within a hundred years, the future of mankind will depend on an understanding and ability to control this source of energy. Now astronomers are asking how it can be that certain galaxies emit prodigious quantities of radio energy—more even than can be expected from nuclear transformations. What will be the practical consequences of studying this problem?

We have seen the development from a study of the movements of the moon and planets to the creation of artificial moons and planets, capable of carrying man-made instruments, machines, and even men themselves. In 13 short years, this capability has expanded our communication capability in ways and to an extent that could not have been imagined less than a generation ago. We do not yet know what the sociological consequences of this new communication capability will be, but it could contribute to the elimination of much of the starvation in India, to a revulsion against war as an instrument of national policy, to a common language in this tower of Babel we call the world. We have already seen the development of means to observe and warn against deadly hurricanes and have envisaged a World Weather Watch which will constantly pour the necessary information into giant computers that can tell us what the weather will be at any point on the globe one or two weeks in advance. With such knowledge and understanding in hand, it seems certain that some measure of beneficial control will follow.

We have measured the size and shape of the earth to an unprecedented accuracy. We have brought back from space pictures of remote areas of the earth, which are useful in designing highways and prospecting for mineral resources, and we hope to expand this activity to enable us to make far better use of our most precious resource, fresh water, and to trace the development and thereby aid in the elimination of diseases of crops and forests. We have developed the capability to photograph military and industrial installations from space, so that very little can be done in secret anymore. We hope that this capability will lead at least to a stabilization of strategic armaments and thereby help us avoid the mutual nuclear catastrophe that haunts our lives.

We can even predict that someday, in orbital workshops free from the

ubiquitous pull of gravity, it will be possible to produce materials that no terrestrial factory could ever hope to achieve—special alloys, special glasses, high-purity vaccines, to mention only a few. And these, in turn, will have consequences that we are not yet able to imagine.

But beyond these practical consequences, there is an area of spiritual consequence that is most difficult to define. The urge of science, as well as of religion, is to comprehend the visible and invisible universe and to find man's place within it. In these matters, religion has historically taken the lead. Questions about man's place in the universe have demanded answers in each generation, and the ancient Hebrews could not wait for the discovery of the neutron, or the development of a theory of stellar evolution, or for biology to explain the variety of life and the origins of man. By means of dramatic imagery, the great religions have provided explanations that have given immediate satisfaction to man's yearning for order in the world and for guidance in his life.

The more prosaic, plodding progress of science, while it may in some cases destroy beautiful edifices of thought that are enshrined in history, at the same time may be preparing the ground for new and even more beautiful edifices to come. In any case, no true humanitarian or religious leader can fail to welcome the advances of science, for they enable him to advance with greater certainty and deeper understanding.

Society today is indeed "in transition." It always has been; it always will be. So long as man is alive, he will continue to ask, "Who am I? Where am I? Why am I here? What is this around me? How can I make it better for myself, my children, and my children's children?" It is the business of science and, in some special ways, of astronomy and space research to provide the knowledge and understanding that alone can answer these questions.

* * *

MOTZ: Dr. Ross Nigrelli, and then Dr. Solco Tromp and Lester Brown.

NIGRELLI: I am going to discuss our aquatic environment and its potential to support and sustain an increasing population, which, it is estimated, will be about six billion in the year 2000. Many estimates of this potential have been optimistic, but most predictions are less optimistic, and rightly so, because no sure methods have yet been developed to estimate the effects of fishing on fish population.

It is true, of course, that with the increase in fishing efforts there has been a gradual increase in the annual harvest of marine fishes in recent years. According to statistics published in 1969 by the Food and Agriculture Organization, the amount of fish caught between 1958 and 1968 increased from 33 million metric tons to 64 million metric tons. The optimists believe that 200 million tons of fish per year can be harvested from the seas on a sustained basis. This represents the total amount of essential animal protein required for six billion people.

Most of the exploitation for food from the sea occurs on the continental shelves of the various nations. It is in such environments that the herring and herringlike fishes, cod and flatfishes, are the major inhabitants, and the species most intensively exploited. These fishes, together with the basses, mackerels, jacks, and tunas, make up a group referred to as the *cardinal species* and comprise about 80 percent of the world catch, mainly by the fishing efforts of about 19 nations, with Japan and the U.S.S.R. the leaders. The remaining 20 percent

of the catch is of unrelated species and is usually taken by countries that lack sophisticated facilities and technical abilities for large-scale oceanic fisheries.

Many scientists believe that the continental shelves are being overexploited. Several fishing areas now produce less than they did ten years ago. For example, the cod population in the Barents Sea is now about ten percent of its former level. In addition, the increase in fishing pressure on the stocks are shown by the smaller average size of the fish and the greater effort needed to catch the same amount of fish.

International commissions are now active in the conservation of the cod and other valuable stocks that are beginning to show a decline in populations. In addition to being overexploited, the available stocks on the shelves are being subjected to increasing contamination by toxic pollutants, some of which may reduce the reproductive potential or make the fish unfit for human consumption. Extending ocean fisheries beyond the continental shelves will no doubt increase the annual production but will require more sophisticated methods in locating and harvesting fishes in the open seas and at a much greater cost per ton.

The tropical regions of the oceans are the least exploited. The catch from Oceania, for instance, doubled in quantity from 1958 to 1968, but the maximum was only 210,000 metric tons. There may be a reason for this, because eating fish from such areas, especially in areas delineated by latitudes 35° N and 34° S, is fraught with danger since many species are poisonous. Fish poisoning is synonymous with ichthyotoxism or ichthyosarcotoxism; but it does not include botulism or poisoning caused by microbial or radioactive contamination or by absorption of pesticides and such industrial pollutants as cyanide or mercury—as has recently occurred in the United States' Great Lakes.

There are several large groups of fishes whose flesh is poisonous when eaten. The most powerful poison is found in the flesh and organs of the puffer family, a group of fish widely eaten by Orientals. The purified poison is a highly lethal neurotoxin with a pharmacological activity 160,000 times more potent than cocaine in blocking nerve conduction. In Japan, this type of poisoning is called *fugu* and is responsible for about 42 percent of the total annual food intoxication. The Japanese Ministry of Public Health and Welfare reported that in the 10-year period from 1954 to 1963 almost 2,000 cases of *fugu* poisoning and 82 deaths have occurred.

The most widely distributed form of ichthyosarcotoxism is called ciguatera. More than 400 species from 11 orders and 55 families of bony fishes have been reported at one time or another as being poisonous, with such desirable species as snappers, jacks, basses, and porgies most frequently affected, especially in the tropical and subtropical waters. About 5,000 cases of intoxication and many deaths have been reported. The development of this poison in otherwise normal fish appears to be associated with the food chain cycle. Carnivorous fish, such as those just mentioned, are most toxic and apparently derive the poison from herbivores that eat toxic blue-green algae, a species of plant life that is more apt to appear as the environment becomes more polluted.

It is apparent, then, that the seas in tropical regions may not prove to be a panacea for protein-starved populations. The reduction of trash fish to fish-protein concentrate, although an important endeavor, must be a highly selective operation. A small number of ciguatoxic fishes accidently reduced to fish concentrate along with normal fish may render the whole batch toxic.

Mariculture, or fish farming as a means of increasing the production of

fish and shellfish, has caught the imagination of fishery scientists and the business community. Although methods can be developed to increase the production of such highly priced items as oysters, clams, mussels, shrimps, mullet, pompano, flounders, and yellowtails, to mention a few, the total tonnage that can be produced on a sustained annual basis will make very little dent in the amount of animal protein that will be required to feed six billion persons, especially the low-income group. It will take many years before fish farming will be economically feasible. It took trout-hatchery scientists more than 50 years to develop their technology to reach the state of production at which we are in 1970.

Many of the same, and even more difficult, problems of management will be encountered before any appreciable numbers of marine organisms can be cultivated and marketed. Fish and shellfish are subject to diseases caused by viruses and other infectious agents, and to diseases caused by nutritional deficiencies, genetic and hormonal imbalances, cancer, and to physiological abnormalities caused by changes in environmental factors. Many problems related to each of these items will have to be solved and at present we know very little about diseases of marine and brackish animals, some of which occur naturally and are known to be transmissible to man.

However, fish comprise only a small fraction of the community of life in the sea. The sea is alive with literally thousands of species of plant and invertebrate life. Planktonic forms are the base of the food web, and the variety of links in the food chain, except for the edible fish species, have been generally ignored. Because of economic, esthetic, and ethnological reasons, most of these living forms, except for certain mollusks and some crustaceans, are not exploited as human food source.

But there is a constant need for fresh sources of drugs, especially new antibiotics, to combat resistant strains of pathogenic bacteria. The unique life mode of many marine organisms suggests interesting chemical and biochemical constituents, and this has in recent years given added impetus to the field of natural-products chemistry. Thus, such animals as sponges, jellyfish, etc., marine worms, and plants of the sea are being studied by biologists, chemists, and pharmacologists as a source of drugs. The number of potentially useful substances that have been isolated from such marine animals and plants has highlighted the need for more intensive biochemical studies. Experimentally, substances from marine organisms have shown a wide variety of pharmacological properties, including antiviral, antimicrobial, cancer-inhibiting, anticoagulant, nerve-blocking, and hypotensive activities. Many have already made their way into the Materia Medica. Eledosin, extracted from a species of Mediterranean octopus, has proved to be an extremely potent hypotensive agent, actually 10,000 times more powerful than quinidine sulfate, the standard drug used as a cardiac depressant.

The living resources of the sea can be exploited for food and drugs to a greater degree, with conservation measures to be imposed on a world basis for some of the more economically important species that are being overexploited. One can no longer consider any area of the total planet in isolation. The increased population has its effects not only in terms of the actual resource it removes from the environment but also by how it deleteriously affects those resources while they inhabit their environment.

FUTURE SCIENTIFIC DEVELOPMENTS IN HUMAN BIOMETEOROLOGY

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Scientific Developments

Introduction

The growing concern of modern society about the scientific and social consequences and political implications of the continuously increasing disruption of the physical equilibrium of our environment, both the atmosphere and hydrosphere (in particular our rivers and lakes), should be a stimulus to the atmospheric scientist not to concentrate solely on basic scientific research. Once in a while he should consider the many physical, sociological, and political consequences of minor changes in our atmosphere and hydrosphere.

To review all aspects of the state of the art in the atmospheric sciences would be an impossible task for any single scientist in this field. Because my own specialty is human biometeorology—i.e., the influence of the atmosphere on man, and on animals to the extent that they directly affect human life—I will concentrate on this aspect of environment and society in transition. However, before discussing this particular aspect of general biometeorology, I would like to consider some of the very important problems in the atmospheric sciences, apart from those in the field of human biometeorology.

Problems related to the study of atmospheric sciences may be divided into two major groups: problems caused by disruption of the natural atmospheric and hydrological environment and problems related to more efficient use of the favorable aspects of the atmosphere and hydrosphere for man, animals, and plants.

Disturbances of the Natural Atmospheric and Hydrological Environment

Disturbances may be caused by man himself, either consciously or unconsciously, or they may be the result of meteorological and extraterrestrial events beyond man's control.

Disturbances Caused by Man: These problems in our complex modern society are manifold, the most important being the increasing amounts of air and water pollution in the highly industrialized parts of the world. These forms of pollution cause great discomfort to man and the animals living in his environment; they are also responsible for serious damaging effects, particularly in plants and the various biological food products and water consumed by man. However, apart from air pollution in the lower atmosphere, little attention has

been given to similar effects in the upper reaches of the atmosphere, the result of man's activity in outer space and supersonic air traffic, which undoubtedly will increase enormously during the next hundred years. In the lower parts of the atmosphere, strong atmospheric turbulence usually helps to reduce the effects of pollution (polluted sections are still a fraction of the unpolluted atmosphere), but in the higher atmosphere these cleansing processes will be less efficient. Disturbances in the upper parts of the atmosphere may affect the ozone layer and ultraviolet absorption from the sun, as well as the electrical field of the atmosphere and, perhaps, other important meteorological forces. Fortunately, the damaging effects in the lower atmosphere are sufficiently known, and they seem to be coming more and more into the limelight. With our present knowledge, the control of this part of the atmospheric environment does not seem to be any more a scientific problem but, in most countries, a purely economic and political one. Simply, it could be solved rather quickly if all industries and governments concerned were prepared to pay for the usually very expensive measures required to curb or end air and water pollution.

Other kinds of man-made problems are those associated with experiments and projects to change our macro- and microclimate, the consequences of which may have not only local but regional effects far beyond the frontiers of a country or continent. Extensive projects to change the direction of flow of large rivers—for example, in the U.S.S.R.—may have very favorable effects for the country itself, but the climatic consequences may also affect large parts of southern Europe and the Middle East. Also, closing the natural sea channels may lead to changes in sea currents, with far-reaching consequences on the climate of coastal areas thousands of miles away.

Human activities affecting the ice layer of the polar regions of the northern and southern hemispheres could alter the level of the oceans and make drastic changes in sea-land boundaries and climates related to these boundaries.

Production of artificial rain has been and is still seriously studied by many meteorological centers; practical application, however, is still restricted. But here again, it is necessary that we fully recognize the consequences of this artificial disturbance of the atmospheric equilibrium.

The use of atomic bombs to change the course of cyclones has been proposed. Needless to say, before attempting this important interference with existing meteorological conditions, we must first carefully predict and study the various consequences that may be expected.

All these problems may yet seem to be wild speculations for the majority of the world's population, but it is not sufficiently realized that similar speculations, put forward only 50 years ago, have pointed to real dangers for our present society.

Man is also interfering with his microclimate both in the buildings in which he is living and in the spacing between buildings. These problems, in the province of architectural and urban biometeorology, will be discussed more fully in a later section of this paper.

Man has also created entirely artificial climates in his homes and offices by air conditioning, and there is an increasing tendency to construct buildings without windows and to use artificial light only. The many physiological consequences of these changes will be discussed later.

Disturbances Caused by Geological and Geophysical Factors Beyond our Control: So-called tectonic movements of parts of the earth's crust, usually accompanied by earthquakes, could affect the present coastlines of the earth's surface and could change the direction of important sea currents, which, in turn, will drastically affect the climate in areas thousands of miles away. Such changes may lead to glaciation of parts of the earth that are now covered by vegetation. Such possibilities must be studied in advance in order for us to be able to predict approaching disasters.

Short and long periodic changes in the macroclimate of certain parts of the earth are common features in the history of meteorology, the prediction of which could have great economic significance. Such changes may be due to minor changes in the position of the axis of the earth (which could be caused, for example, by large-scale mass transport on the surface of the earth) or to extraterrestrial (in particular, solar) influences. It is well known that soon after solar flares are observed, geomagnetic and electric disturbances in the atmosphere can be recorded. Piccardi recently demonstrated similar effects in organic colloids formed during $BiCl_3$ precipitation reactions. However, the effects of extraterrestrial forces on the climate of the earth are usually of a long-term nature. The recent developments of weather satellites may enable us, in the near future, to make long-range weather forecasts that could help predict long-term climatic changes and their effects on food production, as well as their many social consequences.

Apart from the well-known periodic and nonperiodic changes in solar radiation reaching the surface of the earth and the geomagnetic and electric phenomena in the atmosphere caused by extraterrestrial influences, recent studies have shown the existence of various long-term, often periodic, fluctuations in the living world, both in their basic physiological processes and in behavior patterns of animals and man. As mentioned earlier, the physicochemists Piccardi in Italy and Capel-Boute in Brussels observed over more than 20 years fluctuating precipitation patterns of bismuthoxychloride colloids. Their findings have now been confirmed by other investigators in the Southern Hemisphere and Japan. Fischer and his colleagues of the National Center for Atmospheric Research at Boulder, Colo., in the United States also confirmed Piccardi's work. The Colorado studies and recent observations by Eichmeier and Buger in Munich, Germany, suggest that these changes are probably due to electromagnetic radiation that could be extraterrestrial in nature.

Since 1955, using blood sedimentation patterns of large, healthy population groups in the Netherlands and other countries, our own studies also indicate long-term changes that cannot be explained by meteorological patterns, changes in food intake, or social habits.

In the U.S.S.R., Schulz observed similar long-term changes in the leukocyte patterns of 150,000 subjects. Many examples of long-term cyclic patterns in the behavior of animals are known but cannot be explained by the accepted environmental factors. Finally, I would like to mention the recent studies of Weber, Feinberg, Kooy, and others on gravity radiation suggesting the possibility of the existence of gravity particles, the tachyons, moving at speeds faster than light, which are able to penetrate all matter. Instead of gravity forces from within, we may have to consider the existence of gravity radiation pressure from all sides in the universe. This pressure, because of fluctuations in its intensity, could affect all physical and physiological processes on earth in which gravity plays a role. This could be an explanation of the various periodic biological phenomena that cannot be explained by the presently known terrestrial forces.

Problems Related to Better Use of the Favorable Aspects of the Atmosphere and Hydrosphere

Although the study of these problems is mainly preventive in nature, the study of atmospheric sciences in the future, and in particular in the field of biometeorology, could have very important positive aspects. These will be explained more fully in the section on social consequences.

Because of the continuously increasing water and air pollution, man tends to look on the atmosphere and on water as enemies; they could, of course, be our friends—provided future society can understand the enormous amount of beneficial effects of the atmosphere and hydrosphere. The following discussion may clarify our statement.

Principal Physiological Effects Caused by Atmospheric Stimuli

Biometeorological studies, particularly during the last 50 years, have shown that at least 18 important physical and physicochemical types of meteorological stimuli may play an important role in the interrelationships between weather, climate, and man. Among these are: *thermal stimuli* (either through conduction, convection, or infrared radiation with wavelengths of 780–3,000 mm), particularly in combination with humidity and air movement; *light stimuli*, either visible light (380–780 mm) or ultraviolet (290–380 mm), the latter being divided in UV-A (315–380 mm), UV-B or dornoradiation (290–315 mm), and UV-C (290 mm), of which particularly the interval 297–302 mm has significant biological effects; *ionization* of the air; *reduced* and *increased partial oxygen pressure* of the atmosphere as experienced at high altitudes and at great depths in water, respectively; *acidity* of the air; such *trace elements* as ozone and salt; *air-polluting substances*, such as gases as SO_2, CO, CO_2, benzpyrene, etc., such particles as pollen and fungispores causing allergic reactions, or aerosols; olfactory stimulants; *electrostatic* and *electromagnetic fields, microseismic, sonic, and supersonic vibrations;* effects of *gravity and magnetic fields;* effects of *cosmic rays and natural high- or low-energy particles* of radioactive or cosmic origin.

The effect of these stimuli on the living organism depends on which physiological center of the body registers a specific stimulus (particularly the skin, the respiratory tract, the nose, the eyes, and the nervous systems), the past history (law of Wilder), the hour of the day (depending on the natural biological rhythm), the period of the year, and the location on earth. It is only in recent years that the importance of each of these stimuli and receptors has been fully appreciated; we can now more fully understand differences in results obtained by different research workers.

TABLE 1 summarizes the various stimulating forces in the atmosphere and the physiological effects recorded by different centers of the body. In the case of the respiratory tract and nose, it should be noted that temperature and humidity indirectly control significant biological processes that may lead to infectious diseases. The survival of bacteria and viruses in a free atmosphere is mainly dependent on certain temperature, humidity, and airflow conditions, which are usually quite specific for each separate infectious agent. It is, therefore, understandable that each specific climate—sea, forest, mountain, desert, etc.—because of its specific pattern of meteorological stimuli, will have different biological effects.

In modern society, particularly in the U.S.A. with its emphasis on large-scale artificial climates in offices and houses, one is inclined to assume that biometeorological factors have little or no influence. However, studies in our Biometeorological Research Center in Leiden, confirmed by many other institutions, have clearly demonstrated that daily changes in weather conditions affect every animal and man by changing his hormonal and electrolyte balance, thermoregulatory efficiency, etc. If a subject remains out of doors for an hour, and probably even less, he will sustain a physiological imprint for 12 hours or more that is characteristic of the meteorological conditions of that particular day, even if he spends the remainder of the day in an air-conditioned environment with a constant climate.

I have mentioned the thermoregulatory efficiency of man, which enables him to maintain a body temperature within a very narrow interval, between 37° and 40° C. Temperature is partly regulated by thermoreceptors in the skin but primarily by a special organ in the brain, the hypothalamus, which, in turn, controls the pituitary, which, in its turn, controls almost all the hormonal functions in the body. The hypothalamus also influences a part of the brain called the rhinencephalon, which is responsible for many emotional and behavioral states in man. In other words, an efficiently functioning hypothalamus is of vital importance for the physiological and psychological homeostasis of a stable living subject.

Every living organism has an amazing capacity for adapting itself to changing environmental stimuli; however, any individual with a genetically less efficient thermoregulation center or one living under extreme climatic conditions could reach a stage of overstimulation followed by a breakdown in the chain of efficient physiological functions. In large population groups, such breakdowns may cause diseases and social patterns that may affect the economic, social, and political aspects of an area. This is particularly true in many developing countries. But the same applies to large groups of the American and European populations, particularly those living under rather severe climatic conditions, where there are great changes in thermal balance during summer and winter, and often during the same day, or in very windy, e.g., coastal, areas.

It is evident then that intensive study of the application of favorable atmospheric conditions to animals and man could have considerable social consequences for both the highly developed and the developing countries.

SOCIAL CONSEQUENCES AND POLICY IMPLICATIONS OF HUMAN BIOMETEOROLOGY

I am not now going to speak of the obvious social consequences of controlling the atmospheric and hydrological environment by, for example, eliminating air and water pollution. I would like to discuss other, less obvious but extremely important, applications to man of our knowledge about the effects of weather and climate.

TABLE I

PRINCIPLE CENTERS OF THE HUMAN BODY REGISTERING METEOROLOGICAL STIMULI

Skin	Lungs and throat (Respiratory tract)	Nose	Eyes	Direct effects on the nervous system
1 Thermal effects through conduction, convection or infrared radiation recorded by thermoreceptors in skin and hypothalamus, effects counter-balanced by vasodilatation or constriction or sweating. Effects on: (a) Hormonal functions of pituitary (antidiuretic, thyrotrophin and gonadotrophic hormones), thyroid and adrenal gland (17-ketosteroids) and pancreas (insulin production and blood sugar level). (b) Blood: changes in albumin and globulin levels and blood cells composition. (c) Electrolyte balance Cold stress decreases excretion in urine of chloride, sodium, urea, hexosamines, rise in pH. (d) Liver function (transaminases and metabolism) (e) Other physiological processes affected by (a)-(d) 2 U.V. radiation effects: (a) Melanin oxidation (b) Increased vit. D and histamines. (c) Increased gastric acid secretion. (d) Blood: increased haemoglobin, Ca, Mg, and phosphate level (e) Protein metabolism (increase) (f) Hormones: thyroid (hyperthyroidism) and adrenal gland, gonadotrophic functions (g) Direct lethal effects on bacteria. (indirect effect on man). (h) often lowering of reaction speed 3 Changes in acidity of the skin (Marchionini) (a) by aerosols (b) by factors affecting sweat production and evaporation.	1 Temperature and Humidity: affecting mucous membrane Dry air (a) drying and decreased elasticity of mucous membranes (leading to microfissures) and decreased ciliary activity (inefficient removal of dust) (b) decreased mucous (and antibody) production (c) decreased bloodflow and warming up of inhaled air Cooling (a) decreased permeability of membrane (b) constriction of blood capillaries. Affecting survival of bacteria and viruses. 2 Ionization: Surplus of negative ions causes (acc. to Krueger): (a) Increased ciliary activity (from 1100-1700/min.) (b) Increased mucous production due to oxidation of serotonin enzymein trachea. 3 Acidity of the air (a) ph > 8.0: increased permeability, inflation of mucous membrane cells, decreased ciliary activity (b) ph < 7.0: shrinkage of cells (c) ph < 5.0: bronchitis complaints (d) throat mucous usually acid only in 8% alkaline 4 Decreased partial oxygen pressure (a) increased lung ventilation (b) increased adrenal activity (c) increased heart and pulse rate (d) changes in composition of blood cells (e) increased peripheral blood circulation	1 See effects on lungs and throat. 2 Direct stimulation of olfactory-brain (rhinencephalon), affecting mood, cardiovasomotoric, visceral and endocrinal activities. 3 Acidity of nasal secretion normal values pH: 5.5-6.5 pH affects membrane permeability. pH lowers with rest, heating of nose, diluted acetic acid sprays, sleep, acid vasoconstrictors. Also saliva more acid at night. pH rises during rhinitis Acc. to Tweedie with pH 6.5 or lower, negative bacterial cultures. (f) increased thermoregulation efficiency. (g) increased bloodculation in brains (h) improved autonomic functions 5 Increased partial oxygen pressure Treatment of gas gangrene and (anaerobic diseases) phlegmone 6 Trace elements (a) Ozone: In low concentration killing bacteria, in high concentration irritating mucous membranes and increasing infections (b) Salt (NaCl) Fine aerosols with ¼-½% hypotonic salt solution (< 0.9% NaCl) cause swelling of mucous membranes. Hypertonic solutions cause shrinkage. 7 Air pollution (a) Gases: (SO_3, CO_2, benzpyrene etc.) (b) Particles: (1) organic (pollen, spores) causing-allergic reactions (2) inorganic: mineral dust (silicosis etc.) (c) Aerosols: Strong increase of physicochemical action due to increased action surface of small particles and their electric charges	1 Direct overstimulation of the eye causing inflammation 2 Light-flickering of certain frequences activating epileptic attacks 3 Benoit-effect on pituitary (gonadotrophic effects) confirmed by Miline 4 Complete darkness causes changes in carbohydrate metabolism, urine volume, blood sugar level, reduction in size of pituitary, affecting thyroid and adrenal gland (see also U.V. effects on skin). 5 Acidity of the mucous membrane surface of the eyes. important for hordeolum, blepharitis, conjunctivitis, etc.	1 Electrostatic (pulsating) and electromagnetic fields: affecting bees (Schua, Becker, Haine and König), golden hamsters (Schua), nerves (Gengerelli, Thompson), reaction speed (Reiter), plant growth (Murr) 2 Microseismic effects (ampl. 1-20μ) and freq. 6-8/sec.) on eel (Deelder) 3 Direct stimulation of olfactorybrain (see sub. III) 4 Rohracher effect mechanical vibrations of the human body with frequencies 6-12/sec.; amph. 1-5μ. Freq. increases with increased thyroid activity or fever to 14; it disappears after death. It is absent in poikilotherms.

Note 1: Radon effects Studies by Engelmann suggest biol. effects by inhaling radon aerosols (< 80 Mache U.) or drinking radon water (800 MU/L); stimul. of cell functions, oxidizing processes, lowering of Syst. B.P., dilatation of periph. arteries, acceleration of endocrines

Note 2: Magnetic effects Strong (> 1500 Gauss) constant magnetic fields seem to affect cell-rotation, growth of animal tissues, pain-deadening influence, cancer development etc. (see S. W. Tromp; Psychical Physics, 1949, pp. 264-282)

Note 3: Cosmic rays effects. Recent studies by F. H. J. Figge (1947), J. Eugster (1951), S. G. Ong (1962) and others suggest direct biological effects at cellular level due to cosmic rays

Note 4: Gravity field effects: Studies by Bancroft, Briney, Burton, Cooke, Kelley, Smith, Wunder a.o. suggest that accelerative forces for a few minutes to several days cause growth modifications in mice, hamsters, birds, etc. 10-11 day exposure of mice to 2 g. forces causes increase in heat weight (as compared to body weight), weight reduction of the spleen, lowered hematocrit and hemoglobin content, increase in number of phagocytic neutrophils, reduction in rate of body weight gain, etc.

Reduction of Morbidity and Mortality of Major Meteorotropic Diseases

The great significance of future scientific development in human biometeorology can be demonstrated most clearly by considering the social consequences of three major weather-induced, or meteorotropic, diseases that have high morbidity on the American continent and in most European countries: heart diseases, asthma and bronchitis, and rheumatic diseases (particularly different forms of arthritis). We all know that heart diseases are a primary enemy of our modern society and that mortality has constantly increased since 1900. Recent studies at our Research Centre have shown that the average diastolic blood pressure of healthy individuals in the Netherlands has increased during the last 15 years. Monthly mortality from heart disease shows perfect parallels with the average monthly cooling conditions of the atmosphere, i.e., the combined effect of wind, temperature, and humidity. The same is true for other countries. Extreme cold and heat can trigger heart attacks, partly because of poor thermoregulation in heart patients.

Such meteorotropic respiratory diseases as asthma have relatively low mortality, but because the incidence is at least two per 100 in Western Europe, it is not difficult to calculate the loss in working days per year: this does not take into account all the suffering of asthmatics and of those living with them. In the U.S.A., the estimated annual numbers of days lost from work because of asthma and bronchitis is 21,900,000 days, which represent a yearly financial loss of $220,000,000 annually.

A third meteorotropic disease is rheumatoid arthritis. A United States of America survey in 1966 revealed that about 13,000,000 Americans (i.e., one in 15 of the civilian population) suffer from some form of arthritis, causing 186,000,000 days of restricted activity annually, including 57,000,000 days spent in bed and 12,000,000 days lost from work. This represents an economic loss of $220,000,000 annually.

All three diseases are typical meteorotropic diseases: there are major increases in existing complaints (which are also affected by nonmeteorological factors) caused or triggered by weather conditions that unfavorably affect general physiological efficiency, in particular the thermoregulatory mechanism; this mechanism functions particularly poorly in asthmatics and rheumatics.

But not only subjects with these obvious diseases suffer adverse effects. Millions of people in Europe and America and in the developing countries are affected for shorter or longer periods by unfavorable weather conditions, which influence their comfort and working efficiency. A major task for the experts on environmental hygiene in the century to come would be to find solutions for fighting these diseases, not only by using drugs but also by application of the physicochemical stimuli of the natural atmosphere.

Better Use of the Atmospheric and Hydrological Environment in Buildings and Cities for Healthy Subjects

Apart from the various economic and political measures to be utilized in stopping unnecessary air pollution by industries, automobile traffic, and chemical pollution of rivers, several architectural and urban measures must be taken, in addition to the usual sociological requirements for a comfortable building

(such as exclusion of noise from neighbors or from the street, easy access to apartments, sufficient privacy).

Some of the many biometeorological aspects to be studied are the following:

The spacing between and the height and shape of apartment buildings should be such that the wind effects (in particular turbulent ones) at ground level and near balconies are reduced to a minimum in order to lower serious biological effects of cooling.

Sufficiently large green patches should be preserved between each building to allow sufficient exchange of fresh air and solar radiation apart from the esthetic aspects of such design.

Supermarkets and other shopping centers should be well protected from wind and rain, and preferably heated during cold weather, but, at the same time, sufficient natural light should enter the streets—at least in the cold countries. In southern countries, sunlight should be excluded.

The size and location of windows in cold countries should be such that a maximum quantity of daylight enters an apartment. This is necessary because of the important physiological effects of natural light on a number of endocrine functions and the natural daily biological rhythms in man. This measure should be combined with a number of better construction methods, among which are double windows in every building; thermally well insulated walls, floors, and ceilings; adequate and equally distributed space heating; prevention of air currents (so common in imperfectly constructed air-conditioning systems). In other words, measures that would enable a subject to sit or work near such large windows or near outside walls without being subjected to radiation cooling, which seriously affects his thermoregulatory mechanism.

Lack of space prevents further discussion of these points. However, it should be noted that many modern architects accept most of these ideas; unfortunately, in only a few instances are these basic biometeorological principles applied in practice.

Better Use of the Atmospheric and Hydrological Environment for Healthy and Diseased Subjects.

In these times of abnormal social stresses, most healthy people do not have enough time to relax and to profit from the beneficial atmospheric and hydrological environments in their country. In Europe and in the United States of America there are several possibilities for improving the general health and physical comfort of the working population and, therefore, their working efficiency by using modern climatotherapy.

Holidays in Specific Climates, Either Forest, Sea, or Mountain

Each of these climates may have favorable and/or unfavorable effects. A *forest climate* is usually characterized by little air turbulence and, therefore, very little biological cooling and has high humidity, reduced solar radiation, longer-lasting ground fog, and reduced atmospheric electrostatic tensions. For most patients and healthy subjects, this has a very favorable, restful effect; for others, e.g. certain allergic or neurological patients, it may be the opposite.

Sea climates are characterized, at least in Western Europe, by great air turbulence and, hence, strong cooling, great intensity of reflected solar radiation, smaller differences in temperature than inland (winter temperatures being relatively high, summer temperatures relatively low), high humidity, higher percentage of ozone, iodine, magnesium, and sodium chloride in the air than inland, usually few air pollutants (dust, pollen, or chemicals), a smaller number of large ions in the air, and more small ions. These various factors may have, for example favorable dermatological and rhinological effects.

High-altitude climates are marked by a reduced partial oxygen pressure, particularly above 1,500 meters (4,500 feet), and a greater intensity of ultraviolet light (particularly UV-B with wavelengths 297–302 mm, so-called dorno-radiation) together with the presence of very short UV waves with wavelengths of 278. These conditions cause a number of physiological changes in every subject who remains for some time at altitudes above 1,500 m. The important effects are improved lung ventilation; increased peripheral blood circulation, increased hemoglobin content of the blood, adrenal gland stimulation, producing in turn, increased corticosteroids; improved thermoregulation because of increased blood circulation in the hypothalamus, improved balance between the autonomic nervous systems; etc. Asthmatics alternating their residence between altitudes above 1,500 m and sea level can be completely cured after a series of 70–100 treatments; we have demonstrated this in our Research Center with artificial high-altitude climates produced in low-pressure climatic chambers. Each of these climates and their biological effects could be reproduced in large climatotherapeutic centers for subjects for whom long-distance travel is impractical. In the future, many such centers should be built. In winter, many Scandinavians go to Southern Europe or the Canary Islands for such climatotherapy. Large population migrations in winter and summer should be encouraged and scientifically guided. It will help to reduce the effects of stress in our modern life and could improve the health of millions of patients suffering from meteorotropic diseases.

Balneotherapy: Particularly in France, Germany, Austria, Czechoslovakia, Switzerland, and Italy, the use of thermal baths in natural spring water is common. Every year, thousands of healthy but tired people, along with many medical patients, visit these spas. Their expenses are paid by insurance companies or governments. In the Netherlands and the United States of America, most physicians are extremely reluctant to recommend such treatments; they tend to believe that all reported results are entirely psychological. One of the reasons for the negative opinion is the complete lack of research in the Netherlands and the U.S.A. on balneotherapy. Considerable scientific work has been done in Germany on the physiological effects of warm thermal waters. External application affects the adrenal and thermoregulatory systems through thermal stimuli. The various salts, which can penetrate the skin (as demonstrated recently with radioactive tracers), have different biological effects depending on the chemical properties of the water. Finally, long-lasting hydrostatic pressure in the bath has certain clinical benefits. But not only external effects should be considered. Consumption of thermal waters with high salt content undoubtedly has many biological effects.

Thalassotherapy (Seawater therapy): Here again, the same differences of opinion can be observed between physicians in the Netherlands and the United States on one hand and those of Belgium, France, Germany, Italy, Yugoslavia, and the Soviet Union. In the latter countries, physicians strongly believe in the value of thalassotherapy.

In sum, we recommend the establishment of a highly scientific international research center to study the physiological and clinical effects of thalassotherapy, which may help cure, or at least ease, various conditions or diseases of millions of people, which, in turn, will increase the efficiency and production of the working population.

I fully realize that in the United States and the Netherlands, these recommendations will meet strong opposition from the orthodox and often dogmatic leaders in the field of environmental health. The fact that in the past several of the methods described above were used unscientifically and were the domain of charlatans should not prevent modern atmospheric scientists from utilizing their well-established benefits for the well-being of future generations.

Improvement of the Health of the Population and the Economic Expansion of Developing Countries

The present population explosion is creating serious food and space problems. It is not sufficiently understood that a large part of the earth's surface is composed of arid desert areas with extreme meteorological conditions. Better knowledge and control of the atmospheric environments of these areas would help considerably in solving the food and space problems of a rapidly growing world population. If man and his domestic animals can live in greater thermal comfort in these areas and suffer less from diseases caused by the particular atmospheric conditions of the desert, it will affect the mental and social behavior of man and will increase his efficiency in every aspect of social life.

The applications of biometeorology in developing countries have a great impact on the health and economic development of these countries and, therefore, indirectly on their social and political structure.

The applications can be divided into five categories: (1) human, (2) veterinary, (3) avian, (4) phytological (including agriculture and forestry), and (5) urban-architectural.

Human Applications

Although many laboratory studies have been done on the effects of thermal stresses on individual human subjects and animals, large-scale field studies in arid and humid tropical regions are still very rare, and, therefore, the effects of such stresses on the thermoregulatory system are only partly known. It will be necessary to study, in large autochthonous population groups, effects of such stresses, for example, as the separate and combined effects of solar radiation (infrared and ultraviolet) and humidity. In addition, more knowledge is needed about air movement and such normal physiological processes as hormonal production, electrolyte balance, composition and physicochemical state of the blood, reactivity of the autonomic nervous system, changes in antibody levels, and efficiency of the thermoregulatory mechanism. Each of these factors will affect resistance against infectious diseases and influence general health and behavior. The studies should be carried out inland, near the sea, and at high

altitudes above 1,500 m (4,500 ft.). Studies should be conducted in these different geographic areas separately for different sexes, different ethnic and age groups, and different professions.

The influence of the atmospheric environment on many diseases in arid and semiarid regions is insufficiently known, and, therefore, precautionary measures are difficult to determine. Studies should be made on the effects of tropical climates on the development and transmission of infectious agents, the causes of various heart diseases, eye diseases, children's diseases, respiratory diseases, and skin and rheumatic diseases. Last but not least, the effect of extreme climatic conditions on food spoilage and on diseases related to food poisoning should be studied.

Effects of air conditioning on basic physiological mechanisms and on the pattern and development of different tropical diseases as well as on human comfort, behavior, and working efficiency are hardly known despite several studies, e.g. those conducted by the British Navy. All these effects on man may, perhaps, be partly guessed, but little is known for certain. These problems require extensive integrated physiological studies in the decades to come.

Veterinary Applications

The direct effects of climatic factors on domestic animals are frequently of great economic significance. Climatic factors vary from one area to another, and it is indeed for the developing arid and humid tropical areas that data are largely unavailable. Integrated studies of macro- and microclimatic conditions are urgently required, and there is extreme need for analyses of the physiological stresses (including heat, cold, and altitude stresses as determined by temperature, humidity, wind, rain, and reduced oxygen pressure) created by different climates on cattle, sheep, goats, and other domestic animals. Environmental effects on milk production (it is already known that extremely warm, humid climates and cold stresses usually reduce milk production), on skin coat and meat quality, and on reproduction should receive intensive study. For animals kept indoors (because of shortage of land or extreme climatic factors), the microclimatic conditions differ strongly from those experienced by unsheltered animals. For example, the microclimatic conditions in cattle barns may be unfavorable because of humidity and warmth (especially above 20° C) and the presence of such deleterious gases as carbon dioxide and ammonia. Poor floor conditions (such as those associated with uninsulated concrete) may have adverse effects on cattle resting on such floors because the cattle will lose large amounts of heat by conduction to the cold floor.

Some of the unfavorable effects of adverse climatic factors on sheep are well known, but additional studies are greatly needed. For example, a combination of low temperatures with high winds and rain, which penetrates to the skin, destroys the thermal insulation of the fleece and hair coat and may cause serious cold stresses, especially in newborn lambs. Simple shelters in areas of extreme climates may improve conditions that seriously affect the health of domestic animals.

Once climatic factors and the effects of climate become common knowledge, animal breeders will be in a better position to develop breeds adapted to cope with the rigors of extreme climates. Integrated physiological and veterinary research is needed in the study of resistance of different breeds to adverse

climatic conditions and in the selection and crossbreeding necessary for the development of more suitable kinds of livestock. Biometeorological studies are essential to the planning of more adequate methods of control and prevention of tick-borne diseases, helminthiases, and other diseases, the incidence of which is influenced by weather and climate.

Climatic factors also have indirect influences on animals through the kinds of plants available as food in the area. The type of vegetation consumed by grazing animals in a given area is determined by specific climatic conditions and by such soil conditions as trace-element content and toxicity. Much integrated research in this field is required to improve economic conditions in many areas.

Avian Applications

Poultry farming in both arid and humid tropical countries could be improved enormously, and would improve the general economy of these areas, by the application of modern biometeorological knowledge. Weather and climatic factors affecting avian production include, for example, fertility and hatchability, both of which are lower during hot weather; storage of food, with prevention of deterioration (e.g. prevention of loss of water-soluble vitamin A); growth, which may be considerably retarded in hot seasons, even to the extent that growing broilers is impossible during several months of the year; egg production and quality, both of which can be seriously affected by high temperature and humidity (egg production and quality can be maintained at favorable levels even in areas with large fluctuations in diurnal temperatures if the annual and diurnal thermal fluctuations are considered in the design of poultry houses); meat quality, a subject that requires considerably more research; selection of birds, with efforts made to select the best-adapted and most productive fowl in testing stations located in different climatic zones; housing, with special design for maximum comfort and production in various climates; incubation, with special attempts at maintenance of fairly constant incubation temperature and humidity conditions, especially in areas with considerable fluctuation in temperature and humidity; storage of hatching eggs in warm climates; and prevention of deterioration by storage of eggs in well-insulated areas at temperatures of 12–15° C and relative humidity of 75–80 per cent; storage of poultry and eggs intended for consumption, on which special research is needed for arid and humid tropical regions.

Applications to Agronomy and other Areas of Phytological Biometeorology

Application of biometeorology to plant science encompasses two major areas: agrometeorological problems and crop production and protection. In developing countries, a close network of microclimate stations should be established and special conditions and problems investigated in the various regions. Studies are needed of solar and terrestrial radiation and solar-heat loads (for example, on human and farm livestock and on walls and roofs of inhabited structures); in connection with such studies it is necessary to consider evaporation, transpiration, and the technology of irrigation. In cold arid areas, not only precipitation but also snow cover and snow depth should be studied, and in arid regions

attention must be given to atmospheric humidity, dew, and foliage wetness. Wind, wind damage, windbreaks, and shelter-belt problems are also important, as are temperature studies only a few decimeters below the ground surface. These are but a few of the key problems requiring extensive research in developing countries.

Crop production and, therefore, also preharvest protection depend largely on three groups of factors: physical, entomological, and plant-pathological. Such physical factors as the effects of heat and drought and their seasonal distribution on plant growth, fruit bud formation, and the like should be studied along with the effects of cold spells and their seasonal distribution. Increasing attention needs to be given to the effects of air pollution resulting from industrial development and from air-borne salt in coastal areas. More attention should be devoted to entomological factors as related to plant production. Weather and climate studies are needed on (a) the effect of weather on the long-distance migration of insects in tropical regions, (b) the effect of windbreaks on insect distribution, and (c) integrated pest control and spray warnings.

In the area of plant pathology, studies should be made on the geographic distribution of plant pests in relation to weather conditions in different parts of a tropical region and the influence of specific meteorological conditions on the development and spread of such pathological agents as viruses, bacteria, and nematodes in arid and humid tropical regions.

Applications in Architectural Design and Urban Planning

The applications of biometeorological methods to town and city planning and to building design result in the construction of more habitable buildings, which will improve the health and comfort of man and, therefore, his working performance. This is especially true in areas with extreme climatic conditions. Research projects that require the joint efforts of meteorologists, physiologists, urbanists, and architects include the collection and analysis of data and the application of meteorological data to architectural principles: site selections and effect of topography; orientation in regard to solar effects, wind and temperature, solar control, biometeorological gauging of the effectiveness of shading devices and the effects of trees and other types of vegetation; preferable building forms determined by external thermal stresses; wind and airflow effects to satisfy biometeorological needs in public spaces and in structures lacking air conditioning; use of, preferably local, materials for indoor thermal balance and insulation (both inside and outside); and calculation of the thermal behavior of architectural structures in tropical areas.

Weather and Reproduction

Future research and elaboration of preliminary biometeorological findings in the field of human and animal reproduction may have some very interesting social consequences.

Four major aspects of reproduction have been studied so far: the interrelationship between weather and climate and the date of birth of patients suffering from certain diseases, the effect of weather and climate on the incidence of children born with malformations, the influence of weather and climate on sex ratio of newborn children and animals, and the influence of weather and climate on fertility.

Weather, Climate, and Date of Birth

William F. Petersen, formerly professor of internal medicine at the University of Chicago, was one of the first scientists to suggest that metabolic disturbances created by climatic conditions and specific weather stimuli in certain months of the year could determine the propensity to certain diseases on the part of subjects born in such periods. It has only been in more recent years that strong evidence has been found for this assumption.

In 1957, Pasamanick (Director of the Research Division of the Columbus Psychiatric Institute at Columbus, Ohio) and Knobloch traced the month of birth of mentally deficient children born between 1913 and 1948 and institutionalized in the Columbus State School. They found that schizophrenics were born significantly more often in January, February, and March, compared with the standard monthly birth distribution in the United States. Because the third month after conception—the period when the cerebral cortex of the unborn child is becoming organized—would be June, July, and August for this group, any environmental factor during these months that could cause fetal injury might affect intellectual functioning. According to these authors, high temperatures during these months and decreased protein intake might be one of the causes of such trauma. They also found that the number of births of mentally defective children was greater after very hot summers than after cool summers. They were also able to show that the number of abnormalities in pregnancy was significantly higher in January, February, and March than in the summer months (July–September).

De Sauvage Nolting, former psychiatrist at the Psychiatric Institute Den Dolder (the Netherlands), listed the dates of birth of 8,000 schizophrenics in the Netherlands and 7,000 in Great Britain. He found that, after the normal seasonal birth-rate correction, a mathematically significant higher birth rate occurred during February and March and a minimum rate in June and July. No connection with month of birth was found for epilepsy or any mental diseases. De Sauvage Nolting is inclined to account for this distribution by a winter shortage of vitamin C, which would aggravate the genetically determined susceptibility of schizophrenia because the otherwise stimulating effect of vitamin C on the healing process of damaged tissues (e.g. of the uterine mucous membrane) would be considerably reduced in winter.

Similar effects on mental processes are suggested by the studies of Blonsky and McKeown. In 1929, Blonsky observed that the intelligence quotient of schoolchildren in the Soviet Union was highest for chidlren born in the period from January to July (particularly April) and lowest between July and December (minimum in October).

McKeown, of the Institute of Social Medicine in Birmingham, stated that more anencephalics are born in Great Britain in the period October–March (maximum in December) than in the period April–September (minimum in May).

Similar relationships between weather and disease propensity were found by De Sauvage Nolting (using 15,000 patients), Stur (2,800 patients), Dykstra, and others in studies of incidence of cancer. The highest number of birth dates

of cancer patients (after correction for the normal birth frequency of the total population) occurred in the Northern Hemisphere during the months of December–March, the lowest frequency in June–July. The seasonal difference seemed to be independent of the site of cancer.

The practical conclusion of these findings is that if all children in the Northern Hemisphere with a greater likelihood of developing cancer were born in the "favorable" summer months, seven to 11 percent fewer cancer cases could have been anticipated. A similar analysis of 1,240 cancer cases collected by Keogh in Australia confirmed this. The highest frequencies of birth dates of cancer-prone children in Australia occurred in the "favorable" summer months of the Northern Hemisphere, in other words, during the winter months of the Southern Hemisphere.

Also, recent studies by the author, still in progress, of 2,500 patients with diabetes in the Netherlands, suggest a monthly distribution of birth dates significantly different from the normal birth-date distribution in the total population and are different for males and females.

Needless to say, if further studies in other countries could confirm these findings and the meteorophysiological causes could be discovered, preventive measures could be devised to decrease the number of future patients and the yearly expenditures of the public health departments in most of the highly developed countries.

Weather, Climate, and Malformations

In the previous section, we mentioned the observation by Knobloch of a relationship between date of birth and certain abnormalities. Also, the number of anencephalics born in Great Britain suggests seasonal influences. Observations by Kerpel-Fronius and others on seasonal variations in hemorrhagic tendencies and capillary fragility in neonates indicate the significance of weather and climate in relation to birth malformations; this subject has been completely neglected in recent worldwide medical studies of the causes of malformations.

Not only may natural thermal stresses be responsible for a higher frequency of malformations during certain periods of the year, the periods being different in different countries, but also high altitude may have serious effects, as demonstrated by Degenhardt in low-pressure climatic chambers. He observed malformations of the vertebral column in newborn rats as a result of a few hours of artificially lowered oxygen pressure in the environment of pregnant females; the degree of malformation depended on the rate of oxygen deficiency and the day of the experiment; lowered pressures on the ninth day of pregnancy were the most damaging.

Ten Cate demonstrated experimentally in the Netherlands the effect of thermal stresses on embryonic development. A decrease of temperature reduces the amount of oxygen required for chemical processes in cell breathing, but oxygen diffusion is less hampered. In a multicellular embryo without blood circulation, the cells are better supplied with oxygen during periods of low temperature. In the gastrula and neurula stage of the amphibian embryo, Ten Cate observed less lactic acid at lower temperatures. Thermal stresses affected the shape of the neural tube. The gills in amphibian embryos were less developed at low environmental temperatures; they were less branched and less supplied with blood vessels. Temperatures below 12° C also inhibit cholinesterase activity, critical for appropriate functioning of the neural synapses. All these observations suggest that in poorly thermoregulated female subjects living under extreme thermal conditions, both animal and human, malformations can be expected in the growing embryo. Also, the influence of thermal stresses on the activity of the thyroid gland, because of changes in excretion of the hormone thyrotropin, may be responsible for serious disturbances in general metabolism in both the mother and the growing embryo, thus causing malformations.

Weather, Climate, and Sex Ratio

Studies by Riddle and Fisher in 1925 on three species of pigeons kept on the same diet throughout the year showed that in early spring, with increased thyrotropin production and thyroid activity, there was an excess of male offspring but in summer, with diminished thyroid activity, there was an excess of females.

Changing sex ratios were also observed by Adler (1917) and Whitman (1919) in frogs. These thermal effects disappear after transsection of the pituitary stalk. In other words, the hypothalamic-pituitary nerve pathways play an important role in changing sex ratios.

The change in sex ratio could be caused by a true change in sex at the earliest embryonic stages, which would be difficult to understand, considering chromosomal structure, or it could result from the fact that shortly after fertilization statistically more male than female fertilized cells die. This should explain the observation of Petersen that around 1945 in Chicago, the sex of newborn babies was correlated with the weather conditions during the period of conception and more specifically with the average environmental temperatures 285 days prior to birth. Cold-period conceptions favored male babies; female babies were more frequent if conception took place during warm periods.

All these observations may tie in with the observations of Bakwin, Pfaundler, and De Rudder that in summer more girls, or fewer boys, die during the first months of their lives; in other words, the mortality sex ratio (males/females) decreases in summer.

Weather, Climate, and Fertility

In Animals: Thermal stresses and light play an important role in the fertility of animals. It is known that thermal and light stimulation of the hypothalmic nuclei influence the secretion of gonadotropic hormones by the pituitary.

Photoperiodic effects on sexual behavior have been well established by the studies of Assenmacher, Benoit, Bissonette, Hollwich, Miline, Myerson, Neustadt, and many others. Benoit and Assenmacher found that visible sunlight with a wavelength of 380–780 mm affects the optic nerve and visual center of the cerebral cortex, which, in turn, stimulates the supraoptic area of the anterior nuclei of the hypothalamus. Grootenhuis showed that in the Netherlands there is a striking similarity between the yearly conception curve of horses and the curve of the day length in hours. This may be due to the indirect effect of light on the nonprotein sulfhydryl concentration of seminal fluid in horses, which, in turn, determines the sperm motility in seminal fluid. Werthessen and

Haag found a relationship between low concentration, high mortality, and high fertility.

Photoperiodicity is also economically important in poultry science. The laying rhythm of domesticated birds is influenced by seasonal and geographical latitude. In the temperate zones in the Northern and Southern Hemispheres, maximum egg production occurs in the spring; in the tropics, it is equal throughout the year. Along with egg production, sexual maturity is affected. In the northern latitudes, pullets hatched between January and March will reach sexual maturity earlier than those hatched between March and May.

The great effect of high temperature and humidity on fertility in poorly adapted animals has been reported by many research workers; these factors have a strong inhibiting effect, and sexual maturity is delayed, sperm production reduced.

High altitude (3,000–4,000 m) causes in nonadapted animals a reduction in sexual functions and sperm production, but also an increase in embryonic malformations.

In man: Although the influence of meteorological stimuli on fertility is well established in many animal species, it has been very difficult to confirm similar findings in man. Huntington (1938), Mills (1939), and others reported on regular seasonal changes in human birth rates in different countries; the greatest fluctuations were found in the warm temperate to subtropical latitudes, the smallest in subarctic and equatorial regions. These fluctuations are not random but are statistically highly significant, as shown by Takahashi, Rosenberg, and Macfarlane.

Reviewing considerable statistical data on conception rates in different parts of the world, Macfarlane concluded:

1—Spring maxima of conception (usually with a late-winter low) are found in countries with latitudes of 30°–45°, such as Portugal, Spain, Italy, Greece, Yugoslavia, Israel, Syria, Japan (30 per cent greater conception in April than in summer).

2—Summer-autumn maxima occur in countries with latitudes of 45°–70°, such as Finland, Sweden, Germany, Austria, England, Czechoslovakia, Hungary, Canada, and the northern United States.

3—Autumn-winter maxima with a summer depression of conception are found in the seasonal parts of the tropics and subtropics, such as India, Hong Kong, Taiwan, Puerto Rico, and both the humid and dry parts of the Southern United States (28°–38° N. latitude).

4—Winter maxima occur in Southern India, South Africa, North Australia, and Chile.

In relation to mean monthly temperature, Macfarlane observed in cool, temperate climates maximum conception rates at 14°–16° C; in the tropics at 25°–26° (provided the subjects are adapted to this warm environment). Inhibition of conception in cool climates was observed below 11° C, in warm temperate climates around 23° C and above.

These various findings cannot be explained, according to Macfarlane, by season of marriage, national or religious feasts and holidays during certain periods of the year, differences in photoperiod or temperature (e.g. the amplitude of the change of temperature in an area is not necessarily proportional to the amplitude of the change of conception rate).

Lack of space prevents me from discussing these problems in greater detail.

However, the various problems touched on in relation to the influence of the atmospheric environment on four major aspects of reproduction, in the widest sense of the word, clearly demonstrate the many social consequences and policy implications if future studies confirm the facts described. We selected only certain scientific developments in human biometeorology that, in our opinion, are seriously neglected and require intensive research. It is our hope that this review may stimulate other investigators to continue the task.

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THE ENVIRONMENTAL CONSEQUENCES OF MAN'S QUEST FOR FOOD

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Man may have first appeared on earth as early as two million years ago. During perhaps 99 percent of his existence he hunted and gathered wild food, living as a predatory animal. While he was dependent on hunting and gathering for his food, he probably never exceeded ten million in number—the estimated human population that the earth could support under these conditions.

Then, about ten thousand years ago, man learned to domesticate animals and plants, thus initiating the great transition from hunter to tiller. Initially, only a handful of men were attracted to the new agrarian way of life, but through the millenia it has become the preferred way of life. Today only a small fraction of one percent of the human race lives by hunting and gathering. The transition from hunter to tiller is virtually complete. Man has substituted the vicissitudes of weather for the uncertainty of the hunt.

The capacity of man the hunter for intervening in his environment was exceedingly limited, but man the tiller developed a seemingly unlimited capacity for altering his environment, shaping it to his ends. Initially quite simple and limited in scope, his interventions became successively more complex and widespread. Eventually some of the consequences of those interventions exceeded man's understanding of them, creating some worrisome problems. Some of these problems are largely local, but the more serious are global in scale; no respecters of national boundaries, they affect rich and poor alike and are irrespective of ideology. The threat to the environment, and to many forms of life, posed by the steadily growing use of chemicals in farming underlines the common predicament of all mankind as few things do.

Scholars agree that, though still a mystery just being unraveled, the earliest beginnings of agriculture probably occurred in western Asia, in the hills and grassy northern plains surrounding the Fertile Crescent. Wheat and barley grew wild there, as did sheep, goats, pigs, cattle, horses, and deer. To this day, wild barley and two kinds of wild wheat (emmer and eikorn) flourish in the region.

In simplest terms, agriculture is an effort by man to shape his environment so that it better suits his needs. Man selected certain species of animals and plants, which in nature were quite useful to him as a source of food or clothing, and began favoring these species above all others. For example, wheat, a cereal growing naturally in certain areas of the Middle East, is now planted on nearly 600 million acres of land once covered by grass or forest.

The natural cover of some three billion acres, or 10 percent of the earth's land surface, has been removed and planted to crops that man has domesticated. Expressed in these terms, the area cleared by man seems small, but in terms of the area supporting vegetation, it is quite large; in terms of the area potentially capable of supporting crops useful to man, it is still larger, perhaps even predominant. Two-thirds of the cropped area is planted to cereals: rice, wheat, corn, rye, oats, and barley. As a result of man's favoritism to certain species of

animals, the relative importance of various species has been greatly altered. Hereford cattle roam the Great Plains, once the home of an estimated 30 to 40 million buffalo. In Australia, the kangaroo has been largely displaced by cattle of European origin, and the domesticated water buffalo now inhabits all the major rice-growing river valleys of Asia.

Knowledge of farming spread from the Middle East throughout the world. It moved westward across Asia, southward into the Tigris-Euphrates Valley, then along the Nile into Africa and northwestward into Europe, through the Danube Valley and along the Mediterranean coast. Agriculture apparently had independent origins in the Americas and perhaps even in the Far East as well. But these developments came later than the Neolithic achievements in Southwestern Asia.

The great Neolithic achievements of agriculture and husbandry gave man a more abundant and secure food supply, allowing him to increase his numbers and establishing the base for civilization. Grain fields fed growing urban populations. But the problem of obtaining enough food remained; it has plagued man since his beginnings. Technological advances, such as the discovery of irrigation, the use of animals for draft purposes, and the exchange of crops between Old World and New, plus many other technological breakthroughs in more recent times, have greatly expanded the earth's food producing capacity. Spurts in food production have permitted man's numbers to increase, and these increases have in turn exerted pressure on the food supply, forcing man to innovate and devise still more effective means of producing food. In a finite biosphere, we must assume that at some point this reinforcing cycle must be broken.

The history of agriculture is filled with technological advances of varying importance, each of which increased the earth's population-sustaining capacity. A few stand out. The development of irrigation agriculture some 6,000 years ago in the Middle East, probably beginning on the Tigris-Euphrates flood plain, greatly enhanced man's food-producing capacity. It also required a high degree of social organization and closely coincided with the emergence of the early civilizations.

Another of the early farming breakthroughs was the discovery by man at least 3,000 years B.C. that, to augment his own limited muscle power, he could harness certain animals much stronger than himself. Once man learned to use draft animals, he was able to convert roughage into a usable form of energy. Early animal-drawn implements were crude, little more than pointed sticks, and hitches were inefficient implements, often attached directly to the horns of animals. But harnessing this new-found source of energy enabled man to greatly expand his food supply over time.

Among the strongest supporting evidence for the independent origins of agriculture in the Old World and the New World is the quite different crops domesticated in the two regions. Thus, when Columbus established the link between the Old World and the New, he set in motion an exchange of crops between the two worlds that continues to the present. Interestingly, some of the crops were better suited to the world in which they were introduced than to the one in which they originated. As this exchange of crops progressed, the earth's population-sustaining capacity increased steadily.

Perhaps the classic example of this was the introduction of the potato into northern Europe, where it greatly augmented the food supply, permitting marked increases in population. This was most dramatically illustrated in Ireland,

where the Irish population increased rapidly for several decades on the strength of the expanded food supply made available by the potato. Only when potato blight (*Phytophthora infestans*) devastated the potato crop was population checked in Ireland.

Interestingly, the principal source of vegetable oil in the United States and its principal farm export is the soybean, a crop introduced from China several decades ago. Grain sorghum, now the second-ranking feed grain in the United States, after corn, crossed the Atlantic from Africa in the form of food stores on the early slave ships.

The principal source of vegetable oil in the Soviet Union is the sunflower, a plant that originated in the southern Great Plains of the United States. Corn, the only cereal crop indigenous to the New World, is now produced on every continent. The movement of crops between the Old World and the New, and among continents and countries, continues as man alters the nature of the crops themselves through genetic manipulation, as he alters the environment, and as these physical factors interact with the changing demands of the marketplace.

The same factors have influenced the movement of livestock from their areas of origin to other parts of the world. The New World is particularly indebted to the Old for all of its livestock and, with the exception of the turkey, all of its poultry. During the 16th and 17th centuries, the principal dynamics in world agriculture was related to the exchange of crops between the Old World and the New.

Over the past two centuries, scientific advances in the harnessing of mechanical power, in soil chemistry, and in plant genetics have opened new horizons in man's quest for food, permitting him to intervene in his environment more extensively than ever before. Development of the steam engine in the latter half of the 18th century, though it did not profoundly affect agriculture, set the stage for mechanization and the later development of the internal-combustion engine. The internal-combustion engine in the form of the farm tractor introduced a new era in agriculture. Man suddenly had at his command a vast new source of energy, petroleum, which he could use to produce more food. It was now possible to substitute petroleum for oats and hay, to substitute the products of eons-old photosynthesis for that on present-day farms. The substitution of fossil fuels for oats, corn, hay and other feedstuffs increased the potential energy supply per person working the land severalfold. The displacement of horses by tractors in the United States during the first half of the 20th century also released some 70 million acres, once used to feed the nation's horses, for other purposes

During the early 19th century the foundations for another major technological advance in agriculture were established by von Liebeig of Germany, the father of modern soil chemistry. He identified the importance of the nutrients nitrogen, phosphorus, and potassium in plant growth. He demonstrated that one could restore or enhance the soil's natural fertility by adding these nutrients in the proper proportions and, on the basis of this, recommended the use of mineral fertilizers by farmers. Eventually, farmers in their continuing efforts to expand the food supply were to learn to substitute fertilizer for land as the frontiers disappeared.

At the time of von Liebeig's findings, there was still ample opportunity in much of the world for expanding the area under cultivation. Thus, it was not until the 20th century that the use of chemical fertilizers became widespread. As

of 1970, the world's farmers are using more than 40 million metric tons of nitrogen fertilizer alone on three billion acres of cropland, or nearly 30 pounds per acre. Usage varies widely among countries, with intensive use in the densely populated, industrial countries and light use in the poor countries.

In high-rainfall countries practicing intensive agriculture, such as the Netherlands and Japan, a major share of the food supply is attributable to the use of chemical fertilizers, applied in both countries at more than 200 pounds per acre yearly. Stated otherwise, soil fertility would decline rapidly in the absence of chemical fertilizers, dropping food production by half or perhaps as much as two-thirds. On a global basis, perhaps one-fourth of man's total food supply is attributable to the use of chemical fertilizers.

Along with the development of mechanical power and soil chemistry, the third major breakthrough that has contributed so much to man's food-producing capacity was the breakthrough in plant genetics, made possible by the work of the Austrian monk Mendel. From the work of Mendel and his more modern successors, such as Burbank, plant breeders have learned to select, classify, and combine various sources of germ plasm in order to alter plant characteristics. Plant breeders can make plants more tolerant to cold, more resistant to drought, less susceptible to disease, more responsive to fertilizer, and higher in protein content and can alter literally hundreds of other characteristics. To cite some specific examples, they have extended the northern limit of commercial corn production 500 miles within the United States, developed wheats that yield well close to the equator, and increased the oil content of the soybean.

Although the scientific advances that made possible farm mechanization, widespread use of chemical fertilizers, and the dramatic improvement in plants and animals through breeding occurred largely during the 19th century, it was not until well into the 20th century that this knowledge was applied on a widespread commercial basis.

From the time agriculture was first invented until roughly the beginning of the 20th century, the world's food supply increased much more as a result of expanding the area under cultivation than of raising the productivity of land already being farmed. Throughout most of history, man increased the food supply by moving from valley to valley, from country to country, and from continent to continent. Only during the 20th century, as the frontiers gradually disappeared, was man forced to concentrate his energies on raising the yields of existing cultivated areas. The first yield takeoff—the transition from a condition of nearly static yields to that of rapid sustained increases—apparently occurred in Japan at about the turn of the century. Japan's rice yields, which began their sustained rise in the early years of this century, have risen steadily for seven decades except for the interruptions of war. Yield takeoffs apparently occurred in some of the countries of western Europe, such as the Netherlands, Denmark, and possibly Sweden, at about the same time.

But the ability to generate yield-per-acre advances was confined to a relatively small number of countries with advanced farm technologies. The yield takeoff did not occur in North America until about 1940. Between the Civil War and the beginning of World War II, per-acre yields of corn, the principal cereal in the United States, were essentially unchanged.

Although the poor countries of the world did not have advanced farm technologies capable of supporting a rapid increase in output per acre, they were beginning to receive from the industrial countries new medical technologies that greatly reduced death rates, particularly among infants. As a result, their

populations began to accelerate rapidly after World War II, causing the demand for food to outstrip their food-production capacity. Asia, Africa, and Latin America, which had all been net cereal exporters prior to World War II, exporting largely to Europe, suddenly found that their increased populations were consuming what had once been their exportable surpluses. By 1950, the less-developed world was importing several million tons of grain yearly from the developed countries, principally North America. By 1966, this flow of food had increased to 32 million tons, a large part as food aid shipments from the United States. The population explosion in the poor countries thus dramatically altered the pattern of world grain trade.

Cereals are a convenient indicator of food supply because they occupy more than 70 percent of the world's cropland and provide the major share of man's food-energy intake. Wheat and rice each supply one-fifth of man's food-energy supply. With corn and other cereals, they provide more than 53 percent of directly consumed calories and a sizable part of the remainder consumed indirectly in the form of meat, milk, and eggs.

The other important starchy foods are potatoes and other tubers and roots, which provide ten percent of man's caloric intake. Animal fats and vegetable oils, including butter, lard, and oils from peanuts, soybeans, and sunflower, account for nine percent, sugar seven percent, fruits and vegetables ten percent, livestock products 11 percent, and fish one percent. Within any particular locality, diets can vary greatly from this overall global pattern.

Although man's capacity to increase food production has increased several hundredfold since the discovery of agriculture, the majority of mankind is still not well nourished. On the plus side, man has been able to assure the food supply of perhaps one-third of the human race and to eliminate the threat of famine for the remaining two-thirds. For that one-third of mankind living in North America, Western Europe, Eastern Europe, Australia, Japan, and a handful of the smaller countries elsewhere in Asia, Africa, and Latin America, food supplies are now assured. Since the industrial revolution, the productivity and income of those living in the above regions and countries has risen to the point at which, except for a small segment with marginal incomes, diets are now more than adequate. Many people are in fact overfed.

Throughout most of history the threat of famine has been present, usually as a result of droughts, floods, or crop diseases. Occasionally famines are man-made, caused by war or man's inhumanity to man, as in the Soviet Union in 1935–37 and in Biafra in 1969–70; but in the past few decades, the world has been spared from massive famine, except for the man-induced famine in Biafra in 1969–70. Shortly after World War II, the United States decided it had the agricultural know-how and the food production capacity to avoid famine anywhere in the world. This policy was adhered to even when, as in 1966 and 1967, one-fifth of the U.S. wheat crop was required to stave off famine in India. Sixty million Indians were fed entirely by food shipments from the United States for a period of two years.

Since World War II, the global production and distribution system, both among countries and within countries, has evolved to the point where large quantities of food can be moved from one country to another on a sufficient scale to avoid famine caused by any readily envisaged natural catastrophe, such as the monsoon failures on the Indian subcontinent in the mid-60s. Although the specter of famine of the kind that occurred in West Bengal in 1943, costing

some two to four million lives, has been eliminated for at least the time being, human nutrition on a global scale is still in a sorry state. Malnutrition exacts an enormous toll in both the physical and mental development of a great majority of the youngsters in the world today.

The effects of nutrition on physical development is dramatically evident on the streets of Tokyo today. Japanese teen-agers, well nourished from infancy as a result of the enormous rise in income and proper nutrition in Japan, tower inches above their elders. Much of the difference is attributable to a much greater protein intake during early years of life. The effect of good nutrition on physical development is also evident in other ways. In the summer of 1968, India held its Olympic tryouts in New Delhi, with the purpose of selecting a team to go to the Olympics in Mexico City in the fall. Unfortunately, not a single Indian athlete, male or female, met the minimum qualifications for participating in the Olympic competition in any of the 32 track and field events. This, of course, was only partly due to nutrition: dated training techniques and lack of support for athletics were also factors.

Recent studies of malnutrition and mental development indicate a relationship at least as striking as that for physical development. A clinical study of a group of youngsters, severely malnourished before the age of five, conducted in Mexico over a period of several years, indicated an average I.Q. 13 points below that of a carefully selected control group. Studies conducted elsewhere bear out these findings. Unfortunately, these setbacks to development of the brain and central nervous system in early life are irreparable. No amount of feeding or educating in later life can offset it. Protein shortages in the poor countries today are depreciating their human resources for at least a generation to come.

Although the prospects for feeding the projected increases of numbers in the poor countries over the next decade or two appeared bleak in 1966 and 1967 at the time of the Indian food crisis, they have improved measurably over the last few years. The principal reason is the successful introduction and rapid spread in several of the larger poor countries, such as Mexico, the Philippines, Indonesia, Pakistan, India, and Turkey, of the new high-yielding varieties of wheat and rice. This phenomenon, popularly referred to as the Green Revolution, is buying additional time with which to stabilize population growth.

The Green Revolution, based on the much greater responsiveness of the new wheats and rices to fertilizer, which enables them to roughly double the yields of the traditional varieties they replace, is not a universal phenomenon in the poor countries. Cropwise, it is limited largely to wheat and to rice, and geographically, it is limited to those areas with an adequate, controlled water supply. In terms of total cereal acreage, it still accounts for only a small share of the total in the developing countries. Even with these constraints, however, some unprecedented gains in cereal production have been realized over the years. Mexico, which imported one-third of its wheat a generation ago, is today exporting wheat, corn, and rice. Cereal production per person increased each year during the sixties, climbing nearly 40 percent during the decade. The Philippines has ended half a century of dependence on rice imports. Annual increases in wheat yields in Pakistan and India, following the introduction of Mexican dwarf wheats, are double the increases in corn yields in the United States following the introduction of hybrid corn a generation ago. Food aid imports into these two countries are at the lowest level in a decade. The intro-

duction of the new seeds and their associated technologies is clearly not a solution to the food-population problem, but it is buying time with which to stabilize population growth.

In considering future food requirements we must keep in mind that there are two sources of additional demand for food: the first, population growth, is well understood; the second, rising incomes, is not so commonly understood. Present projections indicate world population nearly doubling over the remaining three decades of this century. Assuming that the end-of-century population is no better or worse fed than at present, this would require a doubling of the world's food production capacity.

Rising incomes, an objective of virtually every national government in the world today, will greatly increase claims on the world's agricultural resources. This is perhaps best illustrated by looking at the grain requirements of high- and low-income people. The two billion or so living in the poor countries have available an average of 400 pounds of grain per year. With perhaps 10 percent used for seed, about 360 pounds, or a pound a day, remains for actual consumption. With only a pound of grain available, virtually all must be consumed directly simply to meet minimum energy requirements and to keep body and soul together. As incomes rise, the amount of grain per person that is consumed directly declines, leveling off at about 150 pounds, but total grain used rises steadily, eventually reaching a ton per year as in North America at present. The great bulk of this is consumed indirectly in the form of meat, milk, and eggs. Thus, the claims exerted against the earth's food-producing capacity by those living in the richest countries, say the United States or Canada, are perhaps five times as great as those living in the poor countries.

Advances in food technology are beginning to offset some of the increases in grain requirements in the industrial countries by substituting vegetable products for animal products. This has been most pronounced in the substitution of vegetable oils and shortenings for butter and for lard. In 1940, the average American consumed 14 pounds of butter and 2 pounds of oleomargarine. In 1970, the figures were 6 pounds of butter and 10 pounds of oleomargarine. Lard has been almost entirely replaced with vegetable shortenings. Some 65 percent of whipped toppings purchased in the supermarket are of nondairy origin, as are 35 percent of the coffee whiteners.

Food technologists are now concentrating their efforts on developing acceptable vegetable protein substitutes for various meats. The first major breakthrough has come with a commercially successful imitation bacon derived largely from soybeans. Livestock are rather inefficient in their conversion of vegetable materials into animal protein and fat products, returning only 10 per cent of their energy intake to man in the form of edible food products. Their advantage is that they can consume roughage otherwise of very little use to man. The other 90 percent they use to keep warm and to reproduce and for other purposes. The inherent inefficiency of livestock and advancing food technology have convinced food technologists that they can largely replace many of the livestock products consumed today with products of vegetable origin that are comparable in nutritional quality.

Despite these gains in food technology and the growing acceptance of vegetable-derived livestock substitutes, the overall prospect for the next few decades is for substantially increased claims on the world grain supply as a result of rising incomes. If population projections materialize and economic growth targets are realized, the combined increase in demand could nearly triple world food requirements by the end of the century.

The net effect of the projected doubling in man's numbers and hoped-for future gains in income, particularly among the world's poor, is growing pressure on the earth's agricultural ecosystem. This pressure takes two essential forms: one is extensive, essentially expanding the land under the plow; the other is intensive, the intensification of cultivation on the existing agricultural land area through the increased use of agricultural chemicals, more productive seeds, and the greater use of water.

The price of the extension of cultivation into marginal areas is often the loss of that thin mantle of topsoil, measured on most of the earth's surface in inches, on which man depends for his food supply. Increasing human population invariably results in the clearing of more and more land, either for the production of more food or as a result of the demand for fuel. In the more densely populated poor countries, fuel demands have long since exceeded the replacement capacity of local forests. The result is that the forested area has declined until in many parts of the world there is little left. In these circumstances, as in the Indo-Pakistan subcontinent, people are reduced to using some other source of fuel, such as cow dung, for cooking purposes. The number of people in the world today who rely on cow dung for fuel probably far exceeds those using some of the more modern fuels, such as natural gas.

As man's numbers increase, cattle numbers also increase, denuding the countryside of its natural grass cover. Prof. Robert Brooks, of Williams College, who lived in India for several years, provides a graphic example:

> A classic illustration of large-scale destruction is afforded by the spectacle of wind erosion in Rajasthan. Overgrazing by goats destroys the desert plants which might otherwise hold the soil in place. Goatherds equipped with sickles attached to 20-foot poles strip the leaves of trees to float downward into the waiting mouths of famished goats and sheep. The trees die and the soil blows away two hundred miles to New Delhi where it comes to rest in the lungs of its inhabitants and on the shiny cars of foreign diplomats.

The progressive deforestation that is a result of the population expansion of the last few decades is totally denuding the countryside, creating conditions for rapid soil and water erosion. Millions of acres of cropland in Asia, the Middle East, North Africa, and Central America are being abandoned each year because severe erosion by both wind and water have rendered them unproductive or at least incapable of sustaining the local inhabitants with existing technologies.

It takes centuries to form an inch of topsoil through natural processes, but man is managing to destroy it in some areas of the world in only a fraction of that time. But the problem associated with the loss of topsoil does not end with the abandonment of the severely eroded land. Much of the topsoil finds its way into streams, rivers, and irrigation canals, and eventually into irrigation reservoirs. A dramatic example of this indirect cost of soil erosion is provided by the Mangla Reservoir, recently constructed in the foothills of the Himalayas in West Pakistan as part of the Indus River system. The feasibility studies undertaken in the late 1950s, justifying the eventual investment of $600,000,000 in this irrigation reservoir, were based on a life expectancy of at least 100 years. As the rate of population growth in the watershed feeding the Mangla Reservoir has increased, so has the rate of denuding and soil erosion. The result is

that this reservoir is expected to be completely filled with silt within 50 years or less, rendering it useless for water storage.

History provides many examples of man's abuse of the soil that sustains him. North Africa, once fertile, highly productive, and the granary of the Roman Empire, has lost the natural fertility it once had and is today heavily dependent on food imports under the U.S. food aid program.

The United States has also learned of the costs of overplowing and abusing its rich agricultural inheritance. As a result of overplowing and overgrazing of the Southern Great Plains during the early decades of this century, wind erosion gradually worsened, culminating in the dust-bowl era of the 1930s. The United States responded to this situation by fallowing 30,000,000 acres and by constructing literally thousands of miles of windbreaks in the form of rows of trees across the Great Plains. Had not the U.S. responded in this fashion, much of the Southern Great Plains, like the once-fertile fields of North Africa, would have been abandoned by now.

The alternative to bringing more land, much of it increasingly marginal, under the plow is to shift to more intensive use of existing farmland with agricultural chemicals and other inputs. This brings another set of ecological problems. It is now clear that the use of DDT and other chlorinated hydrocarbons for agricultural and such other purposes as malaria eradication is beginning to threaten at least some species of animal life. DDT is today found in the tissue of many forms of life, ranging from penguins in Antarctica to children in the villages in Thailand. DDT tends to concentrate in animal tissues, particularly fats; among the various species, the highest level of concentration occurs in the more predatory ones.

There is growing evidence that the use of DDT threatens the survival of some of the more predatory species of birds, such as the peregrine falcon, the bald eagle, and others because it affects their calcium formation capacity. The result is thin-shelled eggs, which often do not survive the nesting period. It is unfortunate that the adverse effect of DDT on certain species, particularly some of the predatory birds, is such that some may become extinct before the growing accumulation of DDT in the environment can be arrested. It is ironic that a Swiss scientist was awarded the Nobel Prize in 1947 for developing DDT and that less than a generation later its use is being banned in a number of countries.

Man is perhaps more likely to accumulate higher concentrations of DDT in his tissues than many species because he is an omnivore. The average American, for example, consumes more than 100 pounds of beef each year from animals, which, by virtue of their grazing capacity, are concentrators of DDT. Concentrations of DDT in mothers' milk in the United States now exceed the tolerance levels established for foodstuffs by the Food and Drug Administration.

In his efforts to increase his food supply, man has lately been faced not only with a scarcity of land but an increasingly acute scarcity of water as well. To acquire the amount of water needed, he has been gradually bringing the rivers under control through large irrigation systems. These irrigation systems, such as the Aswan in the United Arab Republic, the Volta River Project in Ghana, the Colorado River system in the United States, and some of the even more massive irrigation systems in Asia, are altering the environment in undeterminable ways. In addition to reducing the annual deposition of fertile silt on the river flood plains and displacing population in the vicinity of the reservoirs, they are creating ideal conditions for the spread of schistosomiasis, a debilitating parasitic affliction that is transmitted to man via snails. Like emphysema in the rich countries, schistosomiasis is an important and growing health problem today because of alterations man has wrought in his habitat in the poor countries. Also known as snail fever, this disease today afflicts an estimated 250,000,000 people, more than any other disease, now that the incidence of malaria has declined.

As the demand for food in the future multiplies as a result of both population growth and rising incomes, particularly among two-thirds of mankind now poor and malnourished, man will be forced to intervene more and more in his environment, often with little understanding of the consequences of so doing. The demand for water for agricultural purposes will probably far exceed that available from conventional sources. Man will then be forced to desalt sea water for irrigation purposes or, what may prove more feasible, alter the world's climatic patterns to shift some of the rain now falling over the oceans over some of the earth's land masses.

This latter requires essentially two technological capabilities. The first is an enormous capacity for gathering information on temperatures, humidity, air mass movements, precipitation, ocean currents, and many other factors. Enough information must be collected to permit construction of a model of the earth's climatic system. Once this is in hand, a computational facility capable of simulating the earth's climatic system, indicating the effect of man-induced changes in climate, is required. Earth-orbiting satellites provide the information-gathering capacity and the latest generation of computers—the computational capability. As is often the case, technology is far ahead of institutions needed to use it effectively. Until a supranational institution is created to analyze, coordinate, and regulate activities in this field, individual countries and firms must exercise restraint in various activities designed specifically to alter climate, particularly those entailing alteration of rainfall patterns.

Forces already in motion, namely the projected increases in world population and planned increases in income, can be counted on to greatly expand the demand for food, requiring man to seriously consider even more far-reaching interventions in his environment well before the end of this century. With a limited amount of new land that can be economically brought under cultivation, future increases in food production must come largely from intensifying cultivation of land already under cultivation. This, in turn, implies that the use of chemical fertilizer must climb sharply, perhaps quadrupling 1970 levels by the end of the century. The use of pesticides must also increase greatly as crop stands become more specialized and more lush and as year-round cropping in the tropics spreads.

At this point in history, it is very clear that there is a need for a new supranational institution to manage the environment, including weather, on a global scale, much as a generation ago the International Monetary Fund was required to preserve and strengthen the international monetary system. Such an institution is needed to provide a framework for global cooperation. It would measure and analyze the impact of man on his environment. It would need to set standards and tolerance levels and to acquire the influence and power to enforce adherence to the standards it set.

Where man's supply of food is concerned, the question is no longer whether we can produce enough food but, rather, what are the environmental

consequences of doing so. As we confront the latter question, there is growing doubt as to whether the earth's agricultural ecosystem can both sustain an end-of-century population of 6.5 billion and accommodate the universal desire on the part of the world's hungry for a much better diet.

* * *

MOTZ: That ends the formal part of our session, and the floor is now open to discussion and questions. I hope that enough ideas have been thrown out to stimulate many questions.

DAVIS: One of the things that strikes me is that we are moving not to the end of science, but perhaps to a new era in science. Science has become more and more specialized, and perhaps we have reached the point where the mere pursuit of increasing specialization will yield very little in the way of results. In the case of the environment this is particularly clear. We are reaching a stage in our work with the environment where we cannot any longer deal merely with one branch; you cannot talk about meteorology, you cannot talk about two-week weather forecasts, without knowing the state of the ocean to a depth of 1,500 meters. You cannot really study the long-term behavior of the atmosphere without knowing the solar cycle and its variations, without knowing the perturbations of the earth on its axis and the interactions this may have with earthquakes.

We are reaching a stage, fortunately, at which, at about the time we are acquiring a universal problem we are also acquiring a universal tool; specifically I refer to the ability to observe the earth's spectrum. We will soon be operational with an entirely new satellite system; in addition to day and night photographs, it will also begin to observe the sun and ionosphere, and within a year or two will sound the atmosphere for both temperature and moisture. By the end of the decade we expect to be able to observe the dynamic behavior of the solid earth, of a motion larger than, say, 10 centimeters. We expect soon to be able to observe the general circulation of the oceans, at least on the surface. We expect soon to be able to observe the temperature of the oceans on a global basis.

All of this represents a universal input, and I think that we are being forced away from specialization into a marriage of disciplines. I hope that perhaps this is the most fruitful direction for science to take. Certainly the fact that we are all sitting here today representing, probably, several dozen disciplines, not only in science but in many other areas of life, is encouraging, and perhaps this is the earliest stage of a new era. In a way, we have arrived at the point in the history of the race where, if we do not start to include our brains in the ecology as well as the rest of us, we are going to be in trouble. And, at this stage, we are beginning to have the tools to do so; I can foresee the time, perhaps 15 years from now, when with a little help we can probably literally computerize the ecology.

But this has some grave consequences for the social scientists, and I hope that this will be discussed sometimes during the meeting because individual freedom has become an issue. Already you no longer have the right to burn trash on Saturday afternoons, and very soon you will lose other freedoms, and nations will lose freedoms. You will not have the freedom to reverse rivers, or stop snow over the Great Lakes if such action is going to have consequences elsewhere in the world.

TISELIUS: Dr. Korff, you have brought out, very carefully, the conflicts between political and technological possibilities; in the pollution area I wonder whether one should perhaps consider waste more as a resource than as a pure nuisance. There are so many examples of this. I mean the possibility of deriving sulfur ferrin from sulfur dioxide. For another example, there is a lot of talk about aquaculture, and there have been suggestions about using low-cost electricity to pump up the rather nutritious deep water from the sea in order to fertilize coastal waters.

What I want to ask, really, is this: Isn't our problem that we are emotionally fragmented in our politicalizations and we don't really integrate to the extent we should? If we look at our problems in much bigger pieces, we will probably come up, from the environmental point of view, with much more acceptable solutions.

KORFF: I don't know whether I am the expert to answer this question, but I think there is no doubt at all that if we regard our waste as a resource, we can do a great deal with it. There are abundant illustration of this. Modern sewage disposal plants turn out useful products from waste matter. It is equally true that a great many other wastes can be processed and used usefully. Ash from burning coal can be used for landfill. There are products from the fishing industry that used to be thrown out; certainly they can be processed and used.

So I think there is no doubt at all that, by the application of the technology that we already have, we know how to do these things. We could do a great deal to benefit ourselves. Our problem is, to some extent, educational. There are many communities in the United States that do not have modern sewage disposal plants, and if you suggest to them that they should install one, they say, "Oh, my, that would cost a lot of money." Therefore we have an educating problem to do.

WADDINGTON: Speaking as a biologist, it has always seemed to me a fantastic situation that half of the energy produced by mankind is thrown away as waste heat; only about half of what we produce we actually use. The majority of standard physicochemical processes cannot make much use of low-temperature heat, but of course biological and enzyme-based processes can. Add an extra five degrees to the temperature of water and you can greatly increase the production of algae. This seems to be a fantastic challenge to biology, which we have not yet properly taken up. These are things we don't yet know the technology for to utilize waste heat, but it is obviously sitting there to be developed. It may be used for cultivating fish or other organisms, which has been investigated in a very small and totally inadequately financed way, or maybe something like solid-state enzymology.

But we have got and we do know of systems that can use low-temperature energy, and there is quantity of energy equal to that which we use now regarded as waste, but waiting to be utilized.

PERRIN: It was stated earlier by Dr. Motz that during the first 25 years of this century two new theories were developed which introduced a fundamental constant: the quantum theory in 1900; and the relativity theory in 1905, with the fundamental constant the velocity of light.

The theory of general relativity was also mentioned, and I would say that this is also really associated with a new fundamental constant, the expansion of the universe. This is not as accurately known, but it may be of basic importance in cosmology, and it is completely new when compared with the relativity theory.

During the past 45 years, essentially no new fundamental basic principles

have been discovered; I agree on this point; however, I would note that that period was the end of fundamental physics, and we have since discovered in physics new, surprising facts, that seem to lead to new, fundamental principles for understanding them. I think that all the effort in high-energy physics, which required a great deal of money, as you know, was well worth it, for example, in seismic research, in which, in the next decade, new fundamental principles will be discovered, similar in importance for understanding the universe to those that were discovered during the first part of this century. I think this is really the justification for all the money spent in this direction. It is essentially for the intellectual benefit of mankind; I don't think that any practical application can come from this new discovery, even if it *is* quite fundamental. It is not because of possible practical application that so much money should be spent on such research; it is for the profit that accrues to the spiritual development of mankind, which may be a luxury, but is quite fundamental to all our modern society.

A few words more about what could be discovered in fundamental science in branches other than high-energy physics: I think that astronomy, with all the marvelous discoveries that have been made, is a field of research in which new fundamental laws in cosmology will perhaps be discovered in the near future; or we may just miss completely, but a large effort in this direction in manpower and money is necessary. And also, in this case, with no practical application in view, it is essential for the better understanding of the universe in which we live that all this work and financial expenditure be carried out.

Of course, in the field of biology it is possible that a new fundamental law of nature may be discovered. But, anyway, the understanding of extremely complex systems, even if there is no new fundamental law of biology involved, is certainly something that, if not basic, is certainly most important for mankind.

In this case, as differing from the other two fields in which I consider that basic research should be developed, we may expect extremely important applications for mankind from the continuing progress of fundamental biology.

So, both for progress in our intellectual understanding and for progress in practical application to medicine, agriculture, etc., we should concentrate on developments in fundamental biology.

On the influence of the environment on life: It was stated this morning that electromagnetic fields might have an effect on life. I don't think this is so. I think it is well established that magnetic fields have no influence whatsoever on the processes of life. Even electric fields may have only indirect effects, such as by changing the contents of dust in the atmosphere, etc. But life is not influenced by electrical fields and certainly not by magnetic fields.

CASSIRER: Dr. Korff and others have established what I think is an essential theme for this conference, the question of options. And Dr. Boyko has also made the point, in the sense of contact with communications media, with the press. Are we going to increase production; at what expense; what will be the impact? This raises two significant questions: one is that obviously—and this is the very theme of the Conference—we can deal with the sciences by themselves and in isolation, and the second is that communication and education is an essential element of our problem. The danger lies in an approach that considers the communications process as one of telling other people, educating other people, as if we knew and they did not know, because finally the options will come from the others; the options cannot come from us.

The whole problem is: How do we establish communications channels of all kinds that enable the decisions to be made by those who are really involved and to be fed back to us, rather than to live with the notion that we here could make these decisions?

DE CASTRO: I believe most of you would agree that the problem of pollution and environmental contamination is primarily a political problem. And, having suggested this, I also suggest that politics is a science also. When people asked Einstein why man, who had discovered atomic energy, had not utilized this energy for the benefit of humanity but to kill people *en masse*, he answered that it was, perhaps, because politics is a much more complicated science than physics. I believe he was right.

It seems to me that pollution is some kind of social disease specialized in by the well-developed areas of the world. The underdeveloped areas, two-thirds of the world, have not yet been entirely contaminated by progress, by industry, and by pollution. So perhaps one point is to avoid spread of this disease by contamination of the other areas that have not yet reached this very bad condition. That is a point that we should perhaps emphasize in a discussion about contamination.

Why has this contamination and pollution developed in such large scale in the overdeveloped areas? Because industrialization and its special technology have no ethics. Until today it has been considered an instrument of interest to increase productivity and its concomitant benefits, but man has been completely forgotten as a piece of the instrument of productivity. But we have never considered that we must protect man from contamination.

I would like to ask: Don't you think we must be careful not to advise the underdeveloped countries to imitate the well-developed countries? Should they undergo the same kinds of development? In other words, that which I call the Utopia of exportation would not be exported because the price would be the increase of bad seeds, and unfortunately we—all the world—will be contaminated.

It seems to me that pollution is something like underdevelopment; it is mainly a political problem. The decade of the development of the undeveloped nations has been transformed into the decade of deception, of frustration, because we have not had any kind of political policy or plan for development. Everything has been improvised, everything has been without a plan.

I think what is essential is that these countries must create their own techniques, so that current techniques will not be encrusted. We must see to it that the ecosystems of these developing areas are not disturbed by the creation of pollution.

BJORKSTEN: Regarding seasons, we have seen that the reproductive response of certain organisms is extremely affected by 15 minutes' variation per day of daylight. And certainly the differences in foods, the greater supplies of vitamins, and different kinds and quantities of proteins that go with various seasons are bound to greatly influence development.

PREGEL: I would like to note that in discussions of contamination and pollution we can't speak about the whole globe, because the contamination is not equal everywhere, so all these problems are not quite the same everywhere. But we certainly cannot dream of reducing the production of energy, as some have suggested. We can find safe ways to produce energy, but nobody can stop technical developments. We have to see how we can use the technology more effectively and safely, and how we can help countries in the developing stages.

THE ENVIRONMENT DOCTOR

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Introduction

Society has come to realize that good manners are essential. Pollution of the environment in all of its multitudinous aspects is now nearly universally frowned on, whether it comes from a belching smokestack or a bus or a car. Also frowned on is the destruction of landscape and delicately balanced ecologies. Nobody is for this kind of activity.

Yet, as everyone knows, we are so locked in certain situations that we seem to have little choice but to follow our present self-destructive course, for a while at least. Take Los Angeles, for example; we all know our main smog troubles are due to the automobile, but each year more cars are driven in the basin. True, the Los Angeles County Air Pollution Control Board, the state Air Resources Board, and the Federal National Air Pollution Control Agency have done several things to reduce the increase rate, yet it still is so large that we ride at pollution levels constituting a serious health hazard. Detroit turns out cleaner new cars, but the old cars remain mainly uncontrolled and continue to keep the levels high.

Turning to another area, northern New Jersey and New York City probably constitute one of the most highly polluted areas from stationary power sources. This is not to say that the automobile does not contribute, for it certainly does, and in a most substantial way, but the single most important source may be industrial and power plants.

And we all know about Pittsburgh and its noble and effective efforts; London's just-emerging efforts; Budapest's joining screams.

It is true that the world is awakening to the need for good manners relative to our environment. Legislation is being enacted right and left and administrators are dashing around looking for quick and at the same time effective solutions, which they are finding to be very scarce unless expensive.

Thus, we come to distasteful choices, such as to ban the internal combustion engine or to choke on smog. Or put several hundred dollars per car into smog devices. Or etcetera. How can anyone deal with such choices? They are so multitudinous and so clearly uncertain as to their effectiveness. There is a great debate in southern California on annual car inspections and required tune-ups. It is clear that if Detroit can be forced to stop air pollution without substantial rise in costs, if the power companies can be made to clean up their effluent gases without substantial rise in rates, if DDT can be banned without bringing back malaria as a major mass killer and a vast drop in farming efficiency due to insects, if we can eat our cake and still have it, then everyone —Republicans, Democrats, everyone—is for the protection of the environment. It is only when the hard choices appear that hesitation comes and the fingers point toward the other fellow.

Obviously something has to be done. With that everyone agrees. The only questions are: "What?" and "How?"

I want to suggest a partial answer to these vital questions. The academic community, the university and the college, can make a very necessary contribution in the technical area. The university is our greatest reservoir of technical talent and experience dedicated to the general welfare, and we now come to the point when we must call on them.

The Environment Doctor

A long career, much of it spent in public service, has taught me a lesson that applies to our present situation and dilemma: the findings as to fact and consequences must be separated from policy-making decisions insofar as is necessary for objectivity. If one feels ill, one does not do his own research and diagnosis, nor does one conduct a poll to determine the cause. One calls a doctor of medicine to assess the situation and to advise on a course of action.

Why is the M.D. called? What is it that he does that no one else can or does do? He takes the broad overview of the health of the individual, consults specialists in the various pertinent fields of the health sciences, and, using all of the laboratory test results and the advice of the specialists, gives a diagnosis and recommends a course of action. The specialists cannot do this, nor can the untrained individual, either singly or *en masse* via the ballot.

The medical doctor's role is that of the expert; he is the objective weigher of the evidence and advice of the specialists. He does not usually make decisions but recommends and counsels.

I vividly recall an experience on the Atomic Energy Commission that in many ways is similar to the present situation, in which public authorities find themselves making decisions of importance to the environment. For very good and sufficient reasons we were pressing hard for the development of our atomic defense armament, but were challenged by critics who cited the dangers of radioactive fallout from atmospheric tests. Also, in the matter of the occupational hazard from radiation by uranium miners and workers in atomic plants across the country from Hanford, Wash., to Savannah River, S.C., controversies grew that had one feature in common: what, in fact, was the level of exposure? In most cases, only experts were able to make such measurements—the levels were lower than those easily measured—and the experts all worked for the AEC or its contractors and, thus, their objectivity was not above question. How, then, were the facts to be brought out for guidance? The joint Congressional Committee on Atomic Energy called us up regularly, and a great volume of expert testimony was produced in this way, but it did not properly and fully answer the question as to the magnitude of the radiation dosages. Of course, the health and genetic effects of small doses, either chronic or acute, are still being intensively researched and debated and will continue to be so as long as our ignorance in this area persists; however, in the matter of the amount, or the question of how to measure the exposure, our knowledge has been adequate for many years and our situation, there in the middle fifties, was that nearly everyone who knew the technique was, in one or another way, beholden to one of the protagonists or contestants—the AEC, or the protestors, or labor unions.

So it was in this context that a new profession was created—that of the health physicist. Contracts for the institution of training courses were let to universities, fellowships for the students were established, and jobs for the

graduates were assured. In this way, the AEC got surcease from the tortuous problems of making its own assay and assessment.

And there is an analogy with our present situation—an analogy so close that, I think, once again we must create a new profession to settle the points of fact and to give the debate the substance it richly deserves: credence and validity.

The new professional will be the Environment Doctor: probably he will formally be called a doctor of environmental science and engineering, but let's call him what he is—the Environment Doctor. His job and role is to bring the facts out, to tell us *before* we take a step what the likely consequences for the environment will be and to tell us how to correct some of our past errors. He will not make the decisions himself, but he will make recommendations to the elected and appointed officials. The objective will be to assure that the decision makers have the best possible information.

We will expect him to be trained in all aspects of physical and ecological science and engineering. He will have the breadth of the M.D. and the same general approach to his profession. His task will be to say what the overall effects on the environment are likely to be for any proposed new action; in order to do this he must be educated in all the aspects of the environment, from meteorology to ecology.

Let us begin the definition of this new profession by excluding functions it will not comprise. It will not include sociology and the political aspects of human behavior. It will not include public health. It will not include these functions because they are covered by existing professionals and it is necessary to limit the scope. Of course, it may be necessary to include courses in general medicine and public health as well as in the social sciences and the law so that the Environment Doctor can properly interact and cooperate with his fellow professionals and the governmental and industrial officials who will be hiring him.

Who will want his services? I would say nearly every judge hearing a case concerning the environment, nearly every government official faced with decisions about it either directly or indirectly, nearly every company executive deciding on plant locations and new product lines, and finally, nearly every lawmaker working on legislation concerning any aspect of the environment.

He will be a licensed professional with a right to practice and serve all customers under his license. He may simply hang out his shingle, or he may be fully employed by some agency or industry, but he will, in all cases, preserve his objective integrity, just as medical doctors and lawyers do now.

He will be trained in a special graduate-school course extending over some five years beyond the bachelor's degree; at the end of this time, he will be licensed by the state and will enter practice. His course of studies will consist of three years of classes in graduate school and two years of supervised field practice, in close analogy to the years of internship and residency for the M.D. degree.

We intend that the first experimental trial be made at U.C.L.A. in a joint effort between the School of Engineering and the Institute of Geophysics and Planetary Physics, possibly with the degree initially administered by an interdepartmental committee. In this way, a trial can be made without serious delay.

If, as we expect, the effort proves popular and effective, we would plan a special school with a separate structure and funding, but all of this would come somewhat later.

At the present time there are only a few well-known practitioners. One is at Stanford, Rolf Eliassen, Professor of Ecology. He took his D.Sc. at M.I.T. in 1935 and practiced civil engineering. Specializing in sanitary engineering, he has branched out into all aspects of air, water, and noise pollution, transportation congestion, and urban sprawl. In 1952, in a famous article in Scientific American, he helps to open the entire subject of water pollution. In a sense, this set him up as a national figure, and his career since has been, in my opinion at least, that of the Environment Doctor.

Another great authority is Ariel Haagen-Smit, of California Institute of Technology, Chairman of the California Air Resources Board, Chairman of the Presidential Task Force on Air Pollution and a leading authority on smog chemistry. Dr. Haagen-Smit has the approach I advocate. He is concerned with the overall effect of air-pollution abatement programs and is never lost in the details. He is no foreigner to politicians and is an adept practitioner himself.

And there are others. Roger Revelle at Harvard, for example. But they are all too few and all much too busy and overworked.

Conclusion

There is hardly a single new idea in this proposal, and yet, in total, it leads to a new course of action—a new profession, a new school at the graduate level, a new dedication and use of technology and technological knowledge and skills stored in the universities. This may help free man to live with the increased population that seems so inevitable. At least it should help him to make better uses of his resources and opportunities.

Dr. Chauncey Starr, Dean of the School of Engineering, and I would like to hear from prospective students. Ideally, such students will possess the equivalent of undergraduate majors in three of five areas—mathematics, physics, chemistry, biology, and engineering. Lesser preparation may require somewhat longer than the anticipated five years of graduate work.

Students with graduate standing could expect to spend less than five years, and graduate Ph.D.s in exceptional cases might need as little as two or three years, consisting mainly of field work. All potential applicants should talk or write to us.

Establishment of a state examining board for issuance of licenses is planned. Details will be published well before the first Environment Doctor graduates, some two or so years from now.

THE DEVELOPMENT OF SEISMOLOGY FROM BIBLICAL TIMES TO 1970

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Seismology has developed chiefly as the result of a need to protect man from the disastrous effects of earthquakes. It would be very difficult to say when earthquakes were first mentioned in history; we have reason to believe that they have occurred on our planet ever since it became a solid. It is likely, therefore, that earthquakes were discussed by the first generations of mankind. One of the earliest recorded references to earthquakes occurs in the Old Testament. In the Book of Ecclesiasticus, written in about 200 B.C., we read (22.14) "Masonry bonded with wooden beams is not loosened by an earthquake. Neither is a resolve constructed with careful deliberation shaken in a moment of fear." This indicates that even in those days some thought was given to earthquake-proof construction. Equally early references to earthquakes can be found in Chinese and other literatures. Robert Mallet, an Irish engineer born in Dublin in 1810, has given us one of the earliest catalogues of earthquakes. Famous for, among other achievements, his designing of buckled plates for the paving of Westminster and other bridges in early London, he became interested in the engineering aspects of earthquakes as a result of reading Lyell's Principles of Geology. He compiled the most complete catalogue of earthquakes of the world up to his time. Using historical records from China, Japan, India, France, Germany, Italy, Switzerland, and the Bible, among others, he listed more than 6,000 quakes occurring between 1606 B.C. and 1850 A.D. He adds some interesting Biblical notes about some of the quakes. He mentions the quake of 1606 B.C. as occurring when Moses brought down from Mount Sinai the Tablets with the inscription of the Ten Commandments. The quake in 1566 B.C. he cites as having caused the walls of Jericho to come tumbling down.

One of the most staid scientific Institutions of the world, The Royal Society of London, founded incidentally by another Irishman, Robert Boyle, states in its Transactions for 1752, "Earthquakes generally happen to great cities and towns. . . . The chastening rod is directed where there are inhabitants, the objects of its monition, not to bare cliffs and an uninhabited beach." Ridiculous as it may seem, earthquakes in some quarters were regarded as supernatural phenomena. In the interest of time, I pass over the early and partly accepted theories that earthquakes were caused by huge dragons turning over or yawning or sighing within Mother Earth. We have rejected such sighs as possible causes but are still not quite sure of the cause of her seisms.

The first attempt at an organized study of earthquakes occurred in Japan in 1880. Of interest to Americans is the fact that a native New Yorker had a part in it. Colonel Van Buren, son of President Van Buren, was American Consul-General in Tokyo in 1876, when a young Englishman, John Milne, came to Tokyo to take over the chair of engineering at the Imperial College. The affinity of language brought the two together and they became friends. On February 22, 1880, in Yokohama—but felt in Tokyo—the strongest earthquake

since Milne's arrival occurred. Milne and Van Buren called a public meeting to discuss the quake, and at this meeting the Seismological Society of Japan was formed, the first such society in the world. Professor Hatori was elected president, and Milne, later Sir John Milne, vice-president. The purpose of the society was to invite international cooperation in an effort to find out as much as possible about earthquakes. From this cooperative effort it was hoped to find some way of lessening the disastrous effects of earthquakes. It must be emphasized that this was by no means the first attempt to study earthquakes. Attempts by individuals to detect and record earthquakes had been made in many countries from very early times. This was the first attempt to organize the study on an international basis. Shortly after the founding of this seismological society, Milne expressed his view that "it is not unlikely that every large earthquake might with proper instrumental appliances be recorded at any point of the land surface of our globe." Nine years later, Milne's prediction was realized. The record of an earthquake from a distance of 5,500 miles was obtained. On April 18, 1889, an earthquake originating in Japan was recorded in Potsdam, Germany, 5,500 miles away, by Rebeur-Paschwitz. Ernst von Rebeur-Paschwitz was born on August 9, 1861. He obtained his doctorate at the University of Berlin in 1883 and became an assistant at the observatory there. In 1884 he set up a horizontal pendulum in Potsdam to try to detect and measure the lunar disturbances of gravity. One day he noticed his pendulum swinging more strongly than any lunar effect could account for. He noted the date and the time. No disturbance of any kind had occurred in Germany or anywhere in Europe to account for the motion. It was later traced to a violent earthquake that had occurred in Japan on that day. This was the first evidence that earthquakes produced effects that could be detected at great distances. The pendulum used by Rebeur-Paschwitz had actually been designed in 1869 to record earthquakes. It was a seismograph, i.e., an instrument designed to record seisms, or shakings.

The heart of a seismograph was then and still is a pendulum. If we suspend a pendulum bob by a fine wire from a frame and attach to the tip of the bob a stylus resting lightly on a glass plate covered with light soot, we have an early form of seismograph. When the ground moves under such a device, the support of the pendulum and the glass plate under the stylus move with the ground. The pendulum bob, however, because of its inertia, resists the ground motion and stays still. The ground motion is thus traced out on the glass plate. Later, the stationary glass plate was replaced by a revolving drum covered with smoked paper. Newton was the first to use the word *inertia*, the Latin word for laziness. In his investigation of the nature of motion, by observing how and why bodies move, he established as his first and fundamental law of motion that all bodies by their very nature have an inherent resistance to motion. (Who likes to get up in the morning?) The heavier the body, the greater its inertia, or resistance to motion. His first law states that all bodies possess inertia. Newton's first law, therefore, is the fundamental principle of the seismograph.

The discovery of Rebeur-Paschwitz spurred the new seismological group to increased activity. Milne considerably improved the sensitivity of existing seismographs by coupling the pendulum tip to the short arm of an optical lever, giving a greatly magnified record on photographic paper. This made it possible for more and more records of distant quakes to be obtained. As these were studied, it became evident that all earthquake records, from whatever station

they were recorded, bore a striking similarity. The beginning of the quake appeared as a sharp impulse. Then the record became comparatively quiet, and several minutes later, depending on the distance of the quake from the observatory, there was a second sharp impulse, of greater amplitude than the first. This was followed many minutes later by long sinuous waves on the record. It was noticed that the time interval between the arrival of the first impulse and that of the second was a function of the distance of the observatory from the quake. Not knowing what these impulses represented physically, they were called the primary, or first, or P phase; the secondary, or S phase; and the long, or L phase of the quake. Since the S, or secondary, phase lagged further and further behind the primary with increasing distance from the quake, it was concluded that the P and S phases represented two phenomena traveling through the earth at different speeds. Robert Mallet, as early as 1860, had suggested that earthquake phenomena probably resulted from elastic waves in the earth. In 1825, Poisson (Annales de Chimie, vol. 36, 1827, pp. 86–93) had deduced from mathematical reasoning that two waves traveling at different speeds should be generated in any solid. Stokes later deduced the nature of these waves as compressional and torsional. It was only in 1900 that the two seismic phases, P and S, were identified as the waves whose existence Poisson had deduced 75 years earlier. R. D. Oldham (Phil. Transactions A, 1900, pp. 135–174) showed this identification in a paper in the Philosophical Transactions in 1900. This identification of the P and S phases as compressional and torsional waves was a great step forward in solving the enigma of earthquakes.

It was assumed that these waves were spherical waves traveling out from the center of the quake to all points on the globe. Nothing was known of the actual path of the waves, still less of their velocity. All that seismologists could register was the time at which these waves struck the crust of the earth at points where an observatory was located to record them. From these quakes whose location and time of origin were known from actual observation, curves were drawn plotting arcual, or great-circle, distance from quake to observatory against time of travel. As more records came in and more observatories cooperated, and more points were plotted the curves became more complete. These curves were known as the travel time curves of P and S. They enabled any observatory to determine its distance from any quake that it recorded. Charts were drawn plotting the great-circle distance of a quake against the time interval S minus P in minutes and seconds. A recent quake off Mexico, for instance, gave a time interval of 5 min 22 sec between P and S. This corresponds to an arcual distance of 2,200 miles from New York. From the orientation of our instruments we established the quake at 2,200 mls southwest of New York. In the early days, the quake distances from three observatories were necessary before the center of the quake could be determined. Three circles were drawn on a globe with the three observatories as centers and their distances from the quake as radii. These three circles would intersect in one point, usually not a point but a small area. This area was then the center of the quake.

Milne left Japan in 1892, after having designed the famous Milne seismograph, which was widely installed. He established his observatory at Shide in the Isle of Wight and was instrumental in forming the seismological committee of the British Association for the Advancement of Science in 1896, which became one of the headquarters for seismic information in Europe.

Most of the work of seismic observatories in the early years consisted in faithfully recording and reporting earthquakes as they occurred. This led to better and more accurate travel time curves of P and S and to an increasingly larger catalogue of the world's earthquakes and the places where they occurred. A map of earthquake centers compiled then and brought up to date shows two main earthquake belts. The larger belt is the Pacific rim, starting with the west coast of South America, coming north along the coasts of Chile and Peru continuing along Central America, Mexico, California, and Alaska, then swinging west along the Aleutians, the Kuril Islands, then south along Japan, the Philippine Islands, New Guinea, New Zealand, and back to South America. Most of the earthquakes of the world occur around this rim. Branching off from this circle at Japan like the handle of a bottle opener, going across China, India, and Iran to the Middle East and ending at the Atlantic end of the Mediterranean (there was a major earthquake in Lisbon in 1755), is the second great earthquake belt.

In addition to these two main earthquake belts, there is a third and minor belt running down the mid-Atlantic ridge. Attention was first called to the existence of this ridge by the engineers who laid down the first transatlantic cable. They noticed a sudden slackening of the cable in the middle of the Atlantic, indicating a rise in ground there. Some few quakes had been recorded from this mid-Atlantic area, but they were few and small. With increased sensitivity of seismic equipment, more and more quakes have been recorded from the ridge. Seismic exploration of the ridge has shown it to be not one but several parallel ridges. Their existence is attributed to the bursting of the mantle through the comparatively thin (5-km) ocean floor millions of years ago. The slow-moving mantle material then flows to either side of the fissure. Subsequent and similar ruptures caused further spreading and further ridges. Similar ridges have been discovered in the middle of all the other oceans, giving rise to a theory of earthquake origin that has gained considerable favor in the last few years. It is known as the plate theory, or plate tectonics. It holds that the earth's crust is divided into a series of plates that move over the mantle relative to one another, much as ice floes slide past one another in the ocean. Because the crustal slipping is in the same direction all around the Pacific rim, the late Dr. Benioff concluded that the Pacific bed is rotating slightly, relative to the surrounding continents. In plate theory, the Pacific plate is moving relative to the continental plate. The San Andreas Fault is regarded as the slipping margin of the continental and oceanic plates. The grinding strain of one plate moving relative to another does not result in continuous motion but in an accumulation of strain that causes a sudden slippage every few centuries. Such slippage is an earthquake. The theory calls for much more research before it will be accepted as factual, but it has great promise.

Prince Galitzin's introduction of the electromagnetic seismograph in Russia in 1906 increased considerably the range and sensitivity of seismographs. Using the well-known principle that when a coil of wire is cut by a magnetic field, a current is generated in the coil when its terminals are connected, Galitzin made his pendulum bob a coil set up in the field of two strong magnets. The latter, attached to the ground, moved with the ground, while the freely suspended coil because of its inertia stayed still. Thus, the ground vibrations were converted into electrical vibrations. Wires from the terminals of the seismometer coil were led to the terminals of a d'Arsonval galvanometer with a mirror attached to its coil. This converted the electrical oscillations into optical oscillations. A light beam directed on the galvanometer mirror was

reflected back and forth on the photographic paper of a recording drum. Nearly all modern seismographs today are electromagnetic. Some use the coil as the pendulum bob with the magnet attached to the frame. Others use the magnet as the pendulum bob with the coil attached to the frame. The most compact of the latter type is the Willmore seismometer, which can oscillate in either the vertical or the horizontal position. A circular coil is attached to the base of the frame of the instrument. Surrounding this coil and enclosing it is a very powerful cylindrical alnico magnet suspended by springs. The inertia of the heavy magnet keeps it still, while the coil moving with the ground, moves in and out of the magnet. The coil terminals are, of course, led off to the terminals of a d'Arsonval galvanometer giving optical registration. If the instrument is turned over on its side, it is free to oscillate horizontally and record horizontal ground vibrations.

In the course of routine recording of earthquakes much side information has been obtained about the structure of the earth. In 1909, for instance, on October 8th, A. Mohorovicic concluded from the examination of the record of an earthquake near Zagreb, in Croatia, close to his station, that the earth has a crust of some 35 km thickness. He was led to this conclusion when he noticed that two P impulses and two S impulses had been recorded by the quake. He correctly concluded that one impulse had traveled directly in a straight-line path from the quake of his seismometer. The second impulse was a wave that had been refracted into a denser lower medium, traveled through this medium at a higher speed than that in the upper medium, and then been refracted back into the upper medium and recorded by the seismograph as it reached the surface.

The discontinuity or line of separation between the crust and the mantle, i.e., the lower part of the earth, has been called the Mohorovicic discontinuity, or simply the moho. The depth or thickness of the mantle was later found to be 2,900 km by Gütenberg in 1913 at the University of Göttingen. The central portion of the earth below the mantle is known as the core of the earth. Such a core had been suggested quite early by several people, on different grounds. Notably among them were Oldham and Wiechert. One reason for its suspected existence was that some observatories failed to record the P and S waves of some quakes. There seemed to be a blind spot, or better, a blind belt on the earth for certain quakes. It was suspected that the waves were being refracted from this blind belt. This proved to be the case, and in 1913, Gütenberg established the depth of this refracting medium at 2,900 km. In 1936, Inge Lehmann (Copenhagen) produced evidence for two cores below the mantle, an outer core, probably liquid, extending halfway from the bottom of the mantle to the center of the earth, and a solid core occupying the rest of the center. This is the view currently accepted by most, if not all, seismologists.

Meanwhile, in 1922, Turner had discovered that all earthquakes do not occur at the surface of the earth as had been hitherto supposed. Some occur at depths as great as 740 km. The writer was working with Professor Turner at the Oxford University Observatory when he made the discovery, which resulted from the routine work of locating the centers of earthquakes whose data had been sent to Oxford. Milne had died in 1913, and his observatory and library, as willed by him, were moved to Oxford, which then became the clearinghouse for seismology in Europe. It is now a matter of routine for both the geographical position and the focal depth of every quake to be established.

The L phase of the early records of quakes, mentioned earlier, was investigated after the routine work of determining quake centers was under way.

The L waves are long sinuous waves of larger amplitude than P and S, continuing for an hour or more in some cases. It was suggested by several (Love, Jeffreys *et al.*) that the long duration of the sinuous waves did not indicate a long duration of the source. The lengthening of the waves was due rather to dispersion or a variation of velocity with period. Longer-period waves travel faster, and the constant lagging behind of the shorter periods gives rise to the long sinusoidal appearance of the record. These surface waves proved to be of two kinds, Love waves and Rayleigh waves. In 1885, Lord Rayleigh predicted that such waves would be generated along the interface of two media in an elastic solid. The Love waves are shear waves trapped within the crust. They have no vertical component. The Rayleigh waves are elliptical waves rolling backward, i.e., like a hoop advancing but rolling in a counter-clockwise direction. Their theory is complicated. Considerable study has been made of surface waves in the last few decades and has thrown much more light on the nature of the earth's crust. The continental crust has been shown to have an average thickness of 35 km, as was earlier determined by Moho. The upper portion of this layer is silicic (granitic) and the lower portion basaltic. The silicic portion is absent under the oceans, where the crust is a 5-km layer of basaltic rock. There is still some uncertainty about whether or not there is a real discontinuity between the silicic and basaltic parts of the continental crust. Majority opinion holds that the change from one to the other is gradual, with no sharp discontinuity.

Now that nuclear blasts and testing have gone underground to avoid sending radiation into the air, the seismograph is the most reliable means of telling what blast has been set off and where. No matter on which side of the Iron Curtain a blast is set off, seismographs on both sides of the curtain tell us where and when and approximately how large they are.

There always will be quakes, but the U.S. Coast and Geodetic Survey, with its international network of 115 standardized seismic observatories in 61 different countries, keeps tab on all quakes that occur. This will lead to measures that will continuously lessen their effects. Any hope of predicting earthquakes is still a long way off, except in such regions as California and Japan, where local measurement of the developing crustal strain is progressing successfully. The hope is that eventually, in these areas, the time when this strain will increase to the breaking point of the crust, with a resulting earthquake, can be determined.

Much seismic research now going on is focused on lessening the secondary effects of earthquakes. One of these effects is the tsunami, or water wave, generated by a quake. By 1972, a geophysical satellite will be placed in stationary orbit 2,300 miles above the equator. It will view the earth from 55° N to 55° S and from 45° W to 145° W. It will be called GOES, Geostationary Operational Environmental Satellite. While primarily meteorological, transmitting atmospheric motion to earth from its cloud cameras, in the event of an earthquake from tsunami regions, detected in Honolulu, it will receive a command signal to switch off its meteorological work and transmit the data from 25 land-based seismographs and five ocean-bottom seismometers. This data will be computer-analyzed at Honolulu. The analysis will determine the estimated time of arrival of tsunami waves, should any occur. Tide-gauge stations, both automatic and manned, will then be commanded by satellite signal to transmit tide-gauge data via satellite to Honolulu. Any tide-gauge records showing tsunami perturbation will be processed, and tsunami warnings with estimated arrival times will be transmitted to all Pacific points.

RECENT ADVANCES IN ASTROPHYSICS

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At the beginning of this century, the study of the stars was still in its infancy, and astrophysics was no more than a word that appeared occasionally in astronomical literature. This was quite natural, for the two great theories of modern physics, quantum mechanics and the theory of relativity, on which astrophysics rests, had not yet been discovered. Astronomers of that period who studied the stars were content with collecting stellar data and with establishing empirical correlations among sets of such observational data wherever they could. Few attempts were made to develop theories of stellar structure because little was known about the structure of atoms or the interaction of matter and radiation. The efforts of astronomers were devoted principally to measuring stellar parallaxes and magnitudes and to the study of stellar spectra. Where the orbits of binary stars were also available, stellar masses were calculated by the application of Newton's law of gravity.

Two important empirical correlations were discovered in the early period —the mass-luminosity relationship and the Hertzsprung-Russell diagram—both of which (particularly the H-R diagram) were to stimulate astrophysical research enormously, and both of which were ultimately to be explained by a detailed theory of stellar interiors.

Because the development of astrophysics depends on the advances in physics, it was only natural that the study of stellar spectra should have dominated astrophysical research in those early days; spectroscopy was then also the dominant branch of physics. When the Bohr theory of the atom and its refinements were developed, the theoretical tools were at hand for understanding the origin of stellar spectra, and the first steps were taken to develop a theory of the Hertzsprung-Russell diagram. But a complete theory of this diagram, which correlates the luminosities of stars with their spectral features (or surface temperatures), had to wait for a correct theory of the internal structure of stars; this is only a recent development and one of the great triumphs of modern astronomy. It is one of the topics I wish to discuss in this paper. The other topics are also related to recent successes of astrophysics and are answers to what appeared to be extremely difficult questions just a few years ago. One of these questions concerns the evolution of stars and the other concerns the origin of the heavy elements in our universe. Both of these questions must be answered together, for the formation of the heavy elements is a consequence of stellar evolution.

The Early History of Stellar Structure

The theory of stellar structure initially developed quite slowly because there was no way to observe the interior of stars, and one could construct a

model only on the basis of the observed surface conditions. The problem that presented itself was, therefore, the following: given the observed surface temperature, the luminosity, and the radius of a star, what must be the interior physical conditions to lead to the observed surface conditions? To avoid having to introduce any specific assumptions about atomic or molecular structure, about which hardly anything was known at the end of the 19th century, such theoreticians as Lane, Emden, and Ritter treated stars as self-gravitating gas spheres to which they applied the Newtonian law of gravitation and the extremely general principles of thermodynamics and kinetic gas theory. These general considerations were sufficient to show that a gas sphere as massive and as large as the sun could be in gravitational equilibrium only if its average interior temperature was of the order of millions of degrees. From this one could also deduce that the central pressure in such a configuration would be millions of atmospheres.

Although these general considerations were important in indicating the physical domain in which the astrophysicist would have to work, they could not lead to a detailed picture of the interior of a star because this depends in a very sensitive way on the manner in which the energy is transported from the interior to the surface of the star. This energy transport, in turn, depends on the way the energy is generated inside stars and on the absorption of this energy by the hot stellar gases through which it must pass to reach the surface. These problems could be solved only after a correct theory of atomic structure had been formulated and some nuclear theory had been developed.

Without a correct atomic theory, and without knowledge about the nucleus, it was still possible to introduce models of stellar interiors if one assumed that the energy was transported entirely by a convective process. This leads to a simple relationship between the pressure and density at each point within a gaseous configuration. If one combines this with the equations of dynamic equilibrium for a self-gravitating sphere of gas, one obtains a simple second-order differential equation for the density at each point. From the solutions of this equation, the pressure and temperature, in addition to the density, can be found at each point of the gas sphere so that a complete model can be constructed. These are the famous polytropes, to which a great deal of attention was paid in the early part of this century. Although these polytropes could not be identified with real stars in any consistent way, they revealed in a very general way that a gaseous sphere not only could maintain itself in equilibrium but also could maintain a constant outflow of energy consistent with the observed luminosities of stars.

The first step away from polytropes and toward our modern picture of stellar interiors was taken by the great British astronomer Sir A. S. Eddington, who pointed out the importance of radiative transport of energy rather than convective transport throughout most of a star's interior. In a series of important papers, starting in 1916 and ending in 1926, Eddington developed the differential equation for the radiative transport of energy, which had to be added to the equations of equilibrium of the gas sphere. He solved these equations for certain special cases and thus developed the first realistic stellar models, even though he did not know the nature of the energy-generating mechanism. He did, however, have available the quantum theory of the absorption coefficient of a high-temperature gas and so was able to solve the stellar interior equations under certain special assumptions about the energy-generating processes inside stars. Without specifying the exact nature of the energy generation, Eddington was

able to construct two general models—the point source model and the famous "standard model."

In the point source model, one assumes that all the energy radiated by the star is generated at the very center so that the flux of energy through the star is constant. The number of differential equations is thus reduced by one, and the remaining equations lead to a quick numerical solution. Eddington's "standard model" was constructed by choosing the opacity of stellar material and the rate of energy generation in such a way that the average of the product of these two quantities remains constant throughout the star. This choice of opacity and energy generation leads to a polytropic model. Although we now know that the "standard model" is unrealistic, Eddington made excellent use of it to obtain an overall picture of the conditions inside stars and to deduce the mass-luminosity relationship for the first time. This showed the power and beauty of analytical methods applied to regions that could never be observed directly. Eddington's work ended the first great phase of the study of stellar interiors and laid the basis for the thermonuclear phase, which began with the discovery of the neutron.

Thermonuclear Reactions and Stellar Structure

The modern phase of astrophysics, as it relates to stellar structure, began shortly after the neutron was discovered and the theory of nuclear structure had begun to develop. The discovery of the neutron permitted physicists to develop a theory of nuclear forces and to study nuclear interactions both experimentally and theoretically. From the experiments and the theory, nuclear cross-sections for a whole range of nuclear interactions soon became available and it became clear that nuclear reactions would occur in an ensemble of nuclei held at a temperature of 10 million degrees or more. The threshold energy (the penetration of the coulomb barrier) required for most nuclei to approach close enough to each other to come under the influence of their mutual nuclear forces and to interact is considerably above 10 million degrees. But it is clear from the Maxwell formula for the distribution of velocities that, at a temperature of 10 million degrees and at densities found near the centers of stars, enough light nuclei—like hydrogen—have energies high enough to interpenetrate their mutual potential barriers. They can thus interact to form compound nuclei and release energy. Astrophysicists immediately realized that this was the mechanism that could account for the generation of energy in stellar interiors, and they quickly began to incorporate the formulae for thermonuclear reactions into the equations of stellar interiors.

The most important work in this field was done by Hans A. Bethe from 1936 to 1940, when he wrote his famous papers on the proton-proton thermonuclear reactions and on the carbon cycle. He demonstrated that at central stellar temperatures of 15 to 20,000,000° the transformation of four protons to He^4 via the carbon cycle could proceed at a rate fast enough to account for the luminosities of stars brighter than the sun. Using the carbon cycle, Bethe and his co-workers, just before the second World War, constructed models for the sun that, though incorrect in detail, gave a reliable overall picture of stellar interiors. Although the accuracy of the measured nuclear cross-sections that were needed for the calculation of the carbon cycle was not very high, enough insight into the problem of stellar interiors was obtained from Bethe's work to

show the importance of accurate opacity and energy-generation formulae. Moreover, these early solar models clearly demonstrated the importance of the hydrogen and helium abundances for the structure of stars. The most abundant nuclear species was hydrogen; helium was second. The carbon cycle, which is highly temperature-dependent, led to solar models with relatively large convective cores and with central temperatures (of the order of 20 million degrees) that were too large.

World War II interrupted this important astrophysical work, and nothing was done until 1946, when M. Schwarzschild took it up again and constructed a solar model using the carbon cycle, but with an improved opacity formula. The model Schwarzschild obtained was essentially the same as the earlier models of Bethe, but it led to a much more accurate determination of the hydrogen and helium content of the sun, and it laid the groundwork for the next great step in the study of stellar structure.

The Upper and Lower Main Sequence Models

Schwarzchild, prompted by the success of his first solar model, laid out a vast research program for the calculation of stellar models in all regions of the H-R diagram, with emphasis to be placed on the discovery of an evolutionary pattern among stars. The early stages of this work, which could not have been started without the aid of high-speed electronic computers, were concerned with chemically homogeneous stellar models that varied only in mass. Schwarzschild and his students showed that the models of stars less massive than the sun correspond to the cool, red stars of low luminosity, lying in the lower right side of the H-R diagram. These stars do not generate energy through the carbon cycle but rather by the direct proton-proton chain, which is not very temperature-dependent. Therefore, these lower-main-sequence stars do not possess a convective core. But Schwarzschild and his co-workers then showed that these stars do possess an outer convective zone, and the larger this outer zone, the smaller the mass of the star.

As one moves up the main sequence of the H-R diagram, the stellar models become more massive, the outer convective zone decreases in size, and a convective core at the center of the model becomes evident. As the mass of the model increases, the convective core increases in size; at the same time the central temperature increases and the carbon cycle becomes more important, ultimately (for large enough masses) displacing the proton-proton chain entirely.

From this basic work by the Schwarzschild group on chemically homogeneous stellar models it became clear that the main sequence of the H-R diagram is a mass sequence. Later investigations by Bennick, Motz, and Linsker, and work by Iben were to demonstrate that the main sequence is a two-dimensional continuum determined by two parameters: the chemical composition (the mean molecular weight of the stellar gases) and the mass. For a given hydrogen and helium content (a given chemical composition) stars arrange themselves along a single curve, which we call the main sequence for that particular chemical composition. By changing the helium content for a fixed hydrogen content we obtain parallel main sequences (or mass sequences) that are displaced vertically downward as the helium content is decreased (increase of the heavy element content).

Because the H-R diagram is a plot of log L vs. log T_e, where L is the

luminosity of the star and T_e is the effective surface temperature, all of the features of the main sequence of the H-R diagram can be obtained from the general relation

$$\begin{aligned}\text{Log } L = &\frac{2}{5}\frac{(10n+27.5)}{(n+2.5)(n+9)}\log \epsilon_0 \\ &+\frac{4}{5}\frac{(n^2+n+5)}{(n+2.5)(n+9)}\log \kappa_0 \\ &-\frac{2(n^2-11.5n+15)}{(n+2.5)(n+9)}\log \mu \\ &+\frac{4}{5}\frac{9n+31}{(n+9)}\log T_e\end{aligned}$$

Here μ is the mean molecular weight and n is the temperature exponent in the energy generation formula

$$\epsilon = \epsilon_0 \rho T^n,$$

where ρ is the density and ϵ_0 is a function of the hydrogen and helium content and of fundamental physical constants. κ_0, which is also a function of the hydrogen and helium abundances, is the coefficient in the opacity formula

$$\kappa = \kappa_0 \rho T^{-3.5}$$

From the above formula for log L, which can be deduced from general homology transformations, one can derive the overall features of the main sequence of the H-R diagram. In particular, the variation of the observed slope of the main sequence with increasing L can be correlated with the change in n as the energy generation passes from the proton-proton chain to the carbon cycle. This is clear if we note that the slope of the main sequence is determined by the coefficient of log T_e.

The variation of the vertical position of the main sequence with chemical composition is determined by the constants ϵ_0, κ_0, and μ, which contain the hydrogen and helium content as parameters. From an analysis of the dependence of ϵ_0, κ_0, and μ on the hydrogen and helium content, one can obtain an overall view of the dependence of the position of the main sequence on chemical composition that agrees well with the results obtained from explicitly constructed models.

Although Schwarzschild was quite successful in constructing chemically homogeneous models that could account for the structure of main-sequence stars, he was unable to construct chemically homogeneous models of giant stars. The reason for this is quite clear if we suppose that a giant star is a homologous analogue of a main-sequence star that can be obtained from the latter by a scaling operation. The virial theorem then shows that the mean temperature inside a chemically homogeneous giant star must be of the order of $\mu H/6k \cdot GM/R$, where μ is the mean molecular weight, H is the mass of a proton, k is the Boltzmann constant, G is the gravitational constant, M is the mass of the star, and R is its radius. If we express M and R in solar units, this becomes $3.84 \times 10^6 \mu(M/R)$. This giant star Capella, whose luminosity is 127 times that of the sun, has a mass four times that of the sun and a radius equal to about 14 solar radii. Capella's M/R value is therefore less than one-third that of the sun, and its mean temperature would be less than one-third that of the sun if Capella were a chemically homogeneous body.

With such a low interior mean temperature, thermonuclear reactions would proceed much too slowly to account for the observed luminosity of Capella. This problem led Schwarzschild to the study of chemically inhomogeneous models for giant stars, and he was able to show that such models can be constructed to give the observed luminosities of giant stars. This was, in fact, the first step in the development of evolutionary stellar models.

The Theory of Stellar Evolution

To see how Schwarzschild was led to a correct theory of stellar evolution, we must consider his early chemically inhomogeneous giant stellar models. In these models there is an isothermal helium core in which energy is released by gravitational contraction but there are no thermonuclear reactions. This core is surrounded by a hydrogen thermonuclear shell, in which the carbon cycle operates and in which most of the stellar energy is generated. This shell, in turn, is surrounded by the great bulk of the star, the radiative outer regions. Schwarzschild quickly realized that such an inhomogeneous model could be pictured as having evolved from the homogeneous main-sequence models that he had constructed previously. This is evident if we note that the most rapid thermonuclear fusion of hydrogen into helium occurs at the center of a homogeneous model, where the temperature is highest. A core of helium will, therefore, eventually develop, and the thermonuclear hydrogen burning will be restricted to a shell surrounding this core. One should therefore find, as Schwarzschild later did, that main-sequence stars evolve away from the main sequence toward the giant branch of the H-R diagram.

The next step in this theoretical development was to construct a sequence of stellar models, the individual members of which were to represent different stages in the evolution of a particular star away from the main sequence. The mass of each member in this sequence of models was to be the same, but the hydrogen and helium contents in each zone of each succeeding model were to be determined by the rate of the thermonuclear reactions in the same zones of the previous model. If Schwarzschild's conjecture were correct, this sequence of models should lead away from the main sequence toward the giant branch, with the oldest model in the sequence being the one with the largest helium core. It would also lie closest to the giant branch. The theoretical models obtained by Schwarzschild and his co-workers had exactly these characteristics, and the theory of stellar evolution was on its way.

To check this theory against observation it was necessary to have models of many families of such sequences, each of which would represent the evolutionary sequence of a star of a given mass away from the main sequence. Since the more massive main-sequence stars are also the more luminous ones, these must be burning their hydrogen more rapidly than the less massive ones. The sequence of evolutionary models constructed for a massive star for a given span of time should therefore show a greater departure from the main sequence (a longer stretch of path in the H-R diagram away from the main sequence) and a larger helium core than that for a less massive star for the same time span. The models of evolutionary sequences for various masses constructed by Schwarzschild behaved in this predicted way.

Schwarzschild was now able to compare this theory of evolution with observation by studying the H-R diagram of globular clusters and open clusters in our galaxy. Any one of these clusters consists of stars with different masses that began their lives (as stars on the main sequence) at the same time and with the same initial chemical composition. This is so because they contracted to their initial main-sequence phase from the same cloud of gas and dust. The gravitational fragmentation of this cloud would result in many self-gravitating spheres, with a variety of masses, ranging from a fraction of the sun's mass to many solar masses, but all with the same chemical composition. The evolution of the more massive stars in this cluster should have progressed more rapidly than that of the less massive stars if the Schwarzschild theory is correct, so that the H-R diagram of such a stellar cluster should exhibit stars distributed along a path part of which lies on the main sequence and a section of which leads from the main sequence to the giant branch. The less massive and less luminous stars, evolving slowly, would still be distributed along the main sequence, but the more massive stars would lie along a path going from the main sequence to the giant branch, with the most massive stars reaching into the giant branch and even beyond. The actual H-R plots of observed clusters show this to be the case, so that strong observational support was lent to Schwarzschild's theory and a new phase of astrophysics was ushered in.

A feverish period of theoretical activity occurred, with high-speed electronic computers playing a dominant role. Ingenious computing programs followed a model of a star from its initial homogeneous phase through a series of thermonuclear stages to some end stage represented by the depletion of all its hydrogen. But it soon became clear that this evolutionary journey of a star would result in much more than just the thermonuclear fusion of protons into helium. Many other thermonuclear reactions would occur as the star evolved; the computing program, therefore, had to be designed to follow the variations in the populations of many nuclear species. This led to fairly complicated evolutionary tracks in the H-R diagram, but the general overall pattern was the same as that discovered by Schwarzschild. The most detailed work in this area has been done by I. Iben and his collaborators.

Evolution Beyond the Giant Branch; Formation of Heavy Elements

The analysis of the early inhomogeneous models of giant stars constructed by Schwarzschild led a number of astrophysicists, particularly F. Hoyle, G. Burbidge, W. Fowler, and A. G. W. Cameron, to investigate the hypothesis that all of the heavy elements that now exist in the universe were formed in the hot interiors of stars after they had left the main sequence. The results of these investigations confirmed this hypothesis.

The problem of the formation of the heavy elements had been a very puzzling one in the early period of thermonuclear astrophysics. Although von Weizsäcker, as early as 1936, had hypothesized that the heavy elements are built up from protons within stellar interiors, this idea was discarded after Bethe showed that all the light elements between ^{1}He and ^{12}C are quickly consumed at temperatures of 2×10^{7} °K and higher, leaving ^{4}He as the end product in all cases. There seemed to be no way for thermonuclear fusion to produce nuclei heavier than ^{4}He. At that time there was no reason to believe that the temperatures and the densities at the centers of even the most luminous stars

were much higher than the corresponding solar values; these values were much too low to produce thermonuclear fusion of the ^{4}He nuclei resulting from the proton-proton chain and the carbon cycle.

This left the question of the formation of the heavy elements very much up in the air, and the burden for the explanation of this problem shifted to the cosmologist. In the early 1950s, Gamow attempted to account for the origin of the heavy elements by postulating the "big bang" theory of the origin of the universe. At best, however, this could account only for the formation of ^{1}He from the primordial protons and neutrons. There is a gap at atomic weight 5 in the table of nuclear isotopes, and the time following the big bang during which the temperature is high enough for thermonuclear fusion to bridge this gap is much too short (about one-half hour) for any appreciable amount of even ^{12}C to have been formed at this initial stage of the universe.

Because cosmology did not have the answer, astrophysicists tackled the problem again and found its solution in the isothermal helium cores of Schwarzschild's inhomogeneous giant models. As Hoyle, Burbidge, Fowler, Cameron, and others pointed out, the helium core in a giant star must contract gravitationally because there is no nuclear release of energy to prevent it. This contraction constantly accelerates because the mass of the core grows steadily as the hydrogen in the surrounding shell is consumed and transformed into helium. The gravitational energy released in this contraction phase causes the temperature of the core to increase steadily until it reaches a value of about 100 million degrees K. At this temperature, as was first pointed out by E. Salpeter, thermonuclear reactions involving three alpha particles (helium nuclei) can occur, resulting in the formation of ^{12}C. Schwarzschild has shown that this reaction sets in quite suddenly, with an initial very rapid release of energy that is referred to as the "helium flash." During this brief flash, the rate at which energy is released in the helium core is 10^{12} times the solar luminosity. The flash causes the helium core to expand just enough to prevent the large initial energy from exploding the star. The core of the star then settles down to a steady state with an orderly thermonuclear transformation of ^{4}He to ^{12}C going on. This is the first stage in the formation of the heavy elements.

It has also been shown by Hoyle, Burbidge, and Fowler, and separately by Cameron, that successive cores of carbon, oxygen, and still heavier elements will occur as the central temperature of the star increases (from continual gravitational contraction) from 100 million to billions of degrees. In time all the hydrogen and helium will have been transformed into such nuclei as ^{16}O, ^{24}Mg, ^{40}Ca, and ^{56}Fe. The still heavier elements can be accounted for by neutron capture, but at this point the star will have become unstable and, depending on its initial mass, will either settle down to a quiet existence as a white dwarf or the more hectic one of a neutron star.

If the initial mass of the star is about equal to that of the sun, the star will reach the white dwarf stage unexplosively or, at least, without any drastic outburst and expulsion of mass. But if its mass is more than twice that of the sun, it will first collapse, compressing its core enormously, and then explode violently, becoming a supernova, with the ejection of a large fraction of its mass. The condensed core will then be evident as a hot neutron star or a pulsar.

Biological and Medical Sciences

Detlev W. Bronk, *Chairman*

Carl-Göran Hedén, C. H. Waddington, *Cochairmen*

BRONK: The first speaker in this session of our conference is Johan Bjorksten.

APPROACHES AND PROSPECTS FOR THE CONTROL OF AGE-DEPENDENT DETERIORATION

Johan Bjorksten

Bjorksten Research Foundation
Madison, Wis.

What can I, an unsophisticated industrial chemist, contribute in this august gathering? Groping for a justification, I can find only that there is perhaps some difference in viewpoint between academic science or the citadels of power of our Government and an industrial chemist who is a playball for many forces vastly more powerful than himself.

If I have any place here at all, it will be to expose to your judgment some concepts that are forced on entrepreneurs whose only choice is to produce results or vanish.

When we approach an industrial problem, the first steps are:

1. Get the target in clear focus.
2. Know what the competition is doing.
3. Reduce the history to charts.
4. Keep it simple.
5. Find the most generic of the possible solutions; in other words, kill as many flies as you can with each swat.

In the following presentation I shall apply this outline.

I. The Target:

To give as many people as possible as many more healthy, vigorous years of life as possible.

II. The Competition:

This is represented by the other principal research activities that use money and manpower: the military, the space effort, nuclear science. These competitors can also at times be allies, but for present purposes the competitive aspects come to mind. What have they given for the money spent? How can we produce results that, judged by the criteria of public good, can justify a higher priority than they now enjoy?

III. Reduce History to Charts:

FIGURES 1–3 show the acceleration of power available to man. What, then, have all the workers on the extension of vigorous, productive life accomplished for the money spent? FIGURE 4 gives the answer.

IV. Keep It Simple:

When I look at the last curve in FIGURE 4 and, as a simple-minded industrial chemist, contemplate the lack of progress that it shows, I recognize a very familiar situation. Only the time scale differs. Change the years to weeks, and this curve could be the sales or production curve of any industrial product whose research has been ineffectual or has long passed the point of diminishing returns.

With this kind of chart I can hear the voice from the other end of a long-distance connection: "If you people don't get busy and produce results in the next three time units, you will be *out*."

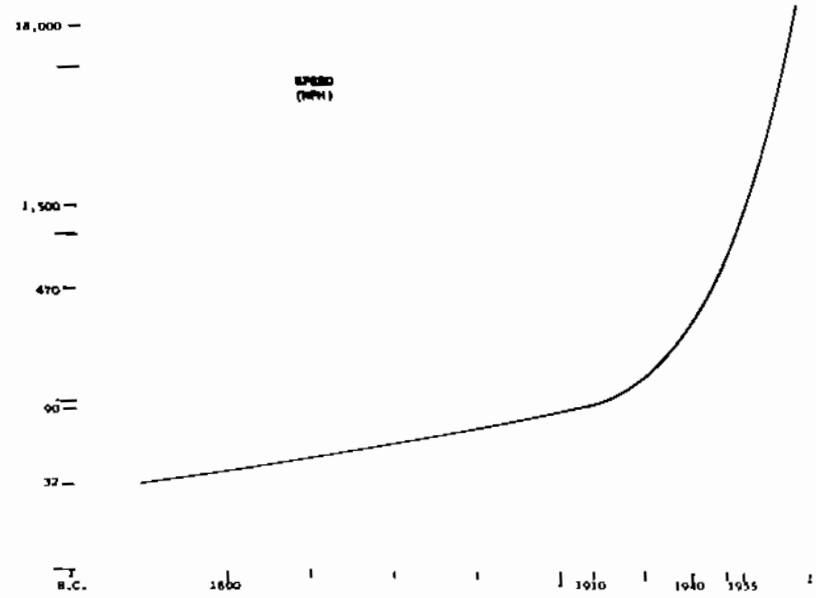


FIGURE 1. The increase in speed available to man and its logarithmic acceleration due to systematic, well-supported-and-directed efforts by the U.S. Air Force, NASA, and supporting organizations.

We have heard that and met the challenge enough times to have remained in business 25 years, so it doesn't alarm us unduly.

What, then, are the possibilities?

In FIGURE 5, A is the present American mortality curve. Curve B is the curve that would result if a cure were found tomorrow for the principal killing diseases of today: the present curve would be moved over about 15 years. The person who did not die of a coronary at 90 would, at age 105, be so much weakened by general aging that he would fall victim to the slightest ailment. Curve C, the flat line, would result if no progress were made on any

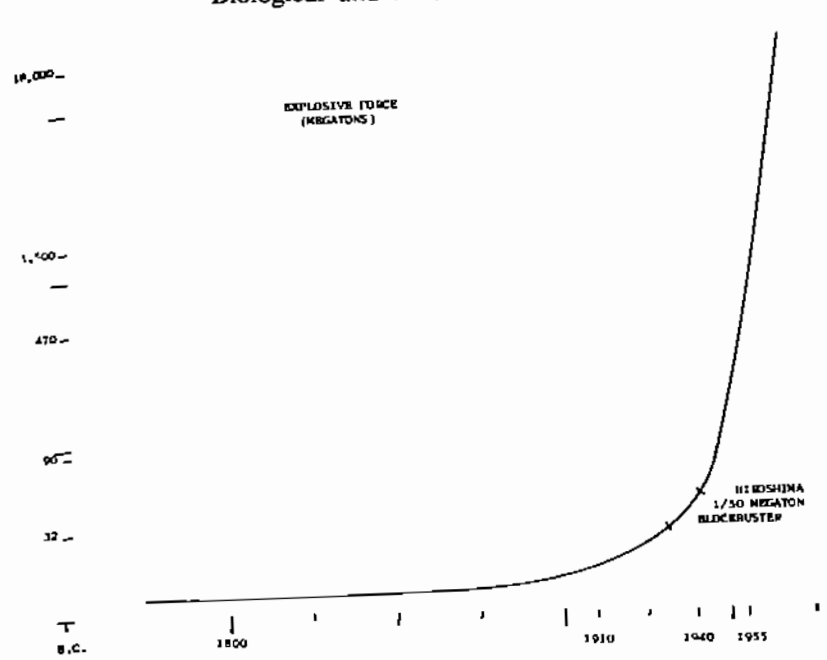


FIGURE 2. The increase in explosive power available and its logarithmic acceleration due to the research activities of the military, the AEC, and supporting organizations.

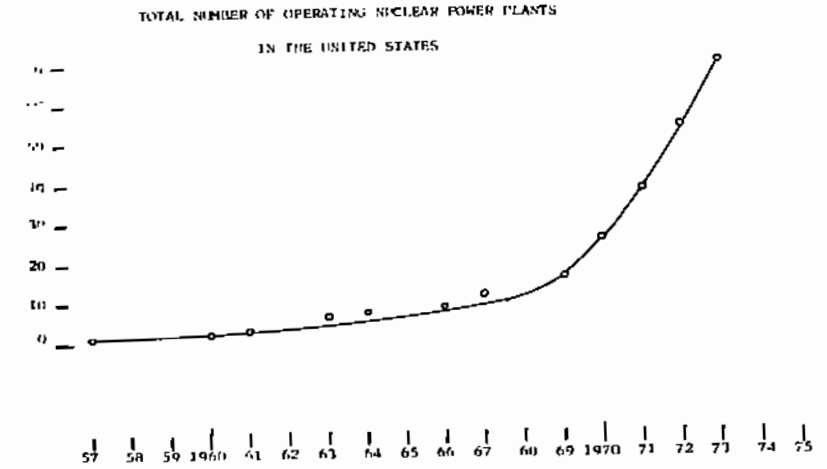


FIGURE 3. The increase in nuclear power generation and its acceleration due to the research activities of the AEC and industry.

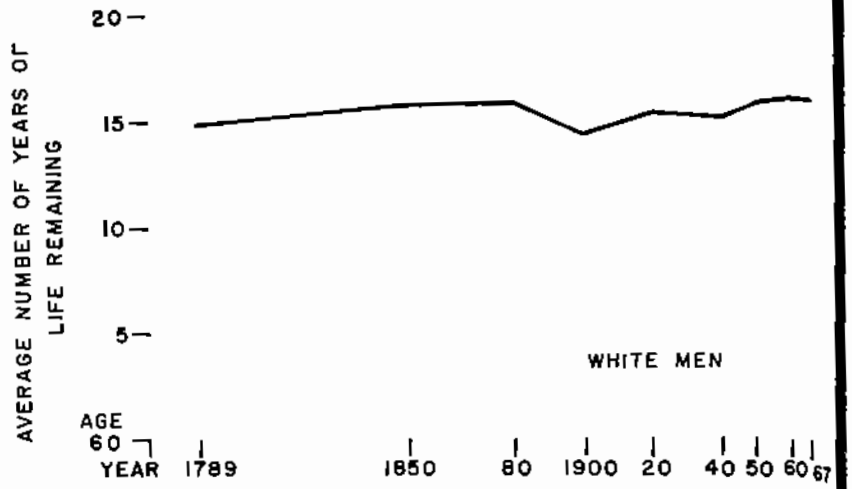


FIGURE 4. Life expectancy at 60 for white males from 1789 through 1967.

of the prevalent diseases per se but the problem of progressive deterioration due to aging were solved. It is evident that the gain would greatly exceed any of the common predictions.

A near-100% success is not unknown in medicine—diseases have all but disappeared—smallpox, plague, most recently, perhaps, polio. But let us be conservative. Few will argue with the notion that a 10% success is a reasonable expectation where systematic, well-directed research is brought to bear. A 10% success in control of aging might be expected to result in curve D.

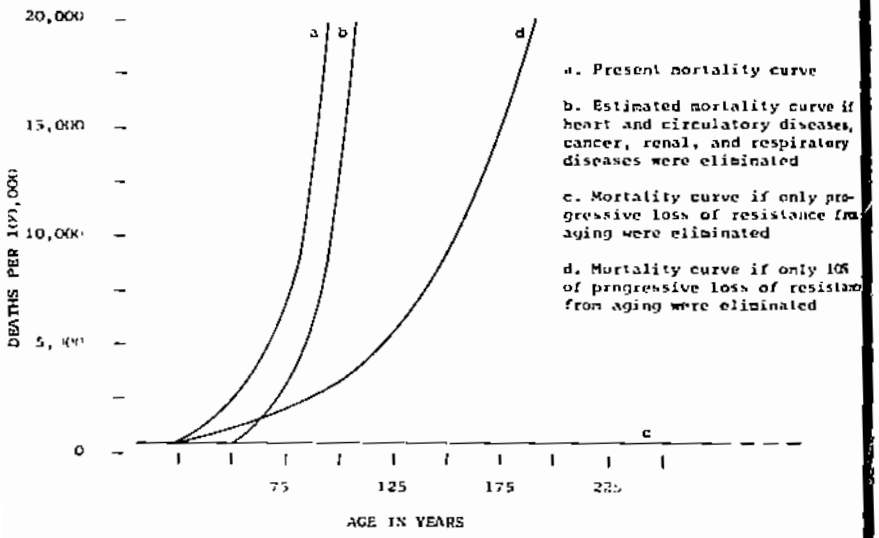


FIGURE 5. Present and projected U.S. mortality curves.

This would lead to a far more tangible result than if all of the research were directed to all of the specific diseases.

V. Kill as Many Flies as Possible with One Swat:

The age dependence of mortality from all diseases is further illustrated by FIGURE 6, from data compiled by R. R. Kohn and published in the Journal of Chronic Diseases (1963).

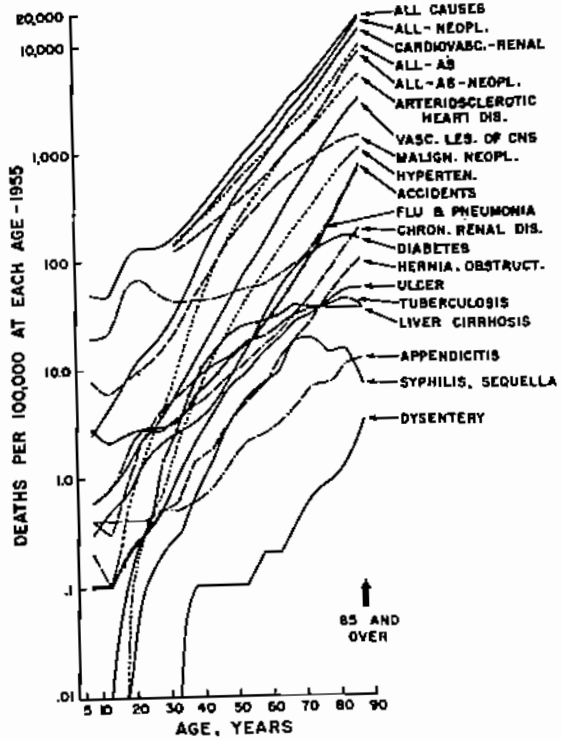


FIGURE 6. Mortality from selected causes by age. Plotted from data compiled by R. R. Kohn and published in the Journal of Chronic Diseases (1963).

We see here that every one of the major diseases tabulated is age-dependent. To attack the problems of these diseases separately, as is now the preponderant course of action, is akin to trying to stop a hemorrhage by closing all of the capillary vessels separately rather than ligating the main artery. It would seem that the present policy of directing most of the medical research to the specific causes of death rather than to the underlying cause or causes of aging and their prevention might benefit from reconsideration. Not only is research aimed at the braking of aging potentially vastly more rewarding, but it may also be easier to pursue. The old fields have been plowed over and over. The field of direct aging research is far less crowded; gold may still be found close to the surface.

The Advantage of a Newer Approach

A few words about recent research, previously unpublished, may serve to illustrate the multiplicity of approaches that can be taken and to show how the field of aging is open to the application of modern research tools and methods.

We fed a pregnant rat a total of 40 millicuries of tritium shortly before it gave birth to a litter and during the first days of lactation. The offspring never received any other radioactive material. One of the litter was sacrificed 621 days later. The tritium still remaining had been fixed in compounds or positions that could not be pried loose by the metabolic forces available to the organism. It was now possible to determine in which form those compounds that contained tritium had been immobilized from birth to far beyond the middle age of the animal.

We did this. The predominant amino acids that had remained fixed in the organism are shown in FIGURE 7. No other radioactive amino acids were found in the separatable peptides.

You will note that these are those amino acids which have side chains (underscored) sticking out from the backbone of the molecule, with a reactive group on the end. If we gave a child toy models of all amino acid molecules and asked it to build a grid, it would pick the amino acids we found. Otherwise there were considerable differences between the fractions. For example, in the liver, the water-soluble radioactivity we found was present in a single peptide composed only of the amino acid serine and a carbohydrate fraction containing ribose. Although the ribose was only 0.05% of this peptide, it contained 90% of the tritium.

The phospholipid fraction, extracted from the residue, was free of amino acids but contained a portion of the tritium administered at birth in the form of unsaturated lipids. It was surprising to us that something as easily oxidized

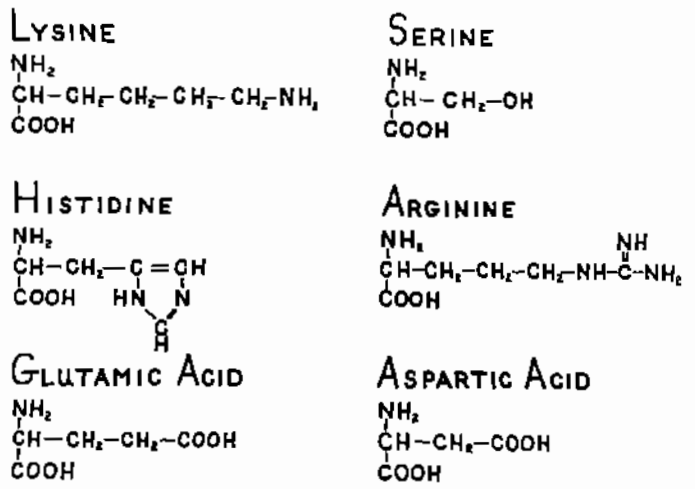


FIGURE 7. Fixed amino acids in 626-day-old rat whose mother was fed tritium during late pregnancy and early lactation.



FIGURE 8. Life expectancy of American white males according to year of birth.

as these lipids could remain fixed through life. These were also found in the corresponding fraction of the brain.

On hydrolysis, at body temperature, of the residue from extraction with water, acetone, and phospholipid solvents, we obtained three polypeptides, of which one consisted of all the amino acids mentioned above and two consisted of the same amino acids except histidine.

The residual matter resisted all milder hydrolysis treatments and was insoluble in all the commonly used biological solvents: 8n urea, urea plus detergents, 6-N guanidine plus detergents, acid and alkaline salt solutions, dimethyl sulfoxide, acetamid, formamid.

It still contained a large share of the total radioactivity present in the animal at death. This is under investigation, but one finding may be mentioned here. We dissolved some of this intractable material in hydrazine-hydrate (95%), passed it over a Dowex-50 column, and eluated a glycopeptide. This substance—80 mg—was hydrolyzed to release the sugars and subjected to further column chromatography. It contained ribose and RNA, and this fraction contained a radioactivity comparable to that of the ribose in the very first water-soluble fraction.

Were these two ribose fractions orignally the same? Was the ribose found in the first, soluble fraction connected with that RNA present at birth which remained functional through the years, and did the ribose found in the last, extremely insoluble, fraction stem from that RNA which was immobilized and rendered nonfunctional by crosslinkage, so as to form insoluble conglomerates or aggregates with other macromolecules?

These findings from our recent work show how results of some significance can still be obtained with ease in the chemistry of aging. Organ transplantations, mechanical or electronical implants, new antibiotics or other drugs, remedies for specific syndromes and diseases—none of these will reach its full potential utility until the progressive loss of resistance due to aging is brought under control.

Even the curve of life expectancy at birth (FIGURE 8) shows that medical

research has reached a point of diminishing return. The life expectancy at 60 of a white male was in 1967 only 1.1 year higher than it was 178 years earlier. Planning must be reassessed. The time for action is at hand. Efforts should not be dissipated on attempts to solve the problems of each disease separately. Their common stem, aging, must be attacked with means and a will at least equal to those applied to problems of space, atoms, or degenerative diseases—which, after all, are only tertiary by-products of aging.

Acknowledgment

I am indebted to the Upjohn Company for permission to publish information obtained with hydrolysates obtained in the course of a project sponsored by them. Dr. P. V. N. Acharya and Mr. Steven Ashman have participated in the experimental work referred to. The Paul Glenn Medical Research Foundation has contributed $2,100 and the Marcus and Bertha Coler Foundation $1,000 to the financing of our relevant research.

* * *

BRONK: As this very interesting paper was being given, I was continually reminded of the fact, familiar to biologists, that anything we do with regard to the process of aging will reveal some of the most important biological processes and understanding of them that we can hope for, because aging and life and the maintenance of life are all part of the same picture.

When reference is made to the tremendous increase in the power available to people with progression and time, I am reminded of one of the frustrations of the present era. While a great deal has happened since the time when man first was able to exercise more force by the use of a lever until the present, when, by turning a switch, he can gain far more power from nuclear-energy procedures, nevertheless, the use of the lever has given to man, as a man, greater power, and it still is available, whereas the vastly greater power of which you spoke is not available to man as a man, but as one of a vast aggregate of people.

I think of the same analogy in regard to communication from the days when man first used signal fires to communicate greater distances than he could communicate with his own, unaided voice, to now, when we use Telstar. But man as a man cannot communicate by Telstar, but only as one of a vast number of people, and that, I think, was the historic significance of that historic sentence uttered by the astronaut when he first stepped upon the moon, "One small step for man; a giant stride for all mankind."

So while we tend to think of a vast increase of our energy into communication and all the devices that technology has conferred on mankind, individual man still is limited to a very considerable degree.

Next is Dr. Kurt Hirschhorn.

ON RE-DOING MAN *

Kurt Hirschhorn

Mount Sinai School of Medicine
New York, N.Y.

The past 20 years and, more particularly, the past five years have seen an exponential growth of scientific technology. The chemical structure of the hereditary material and its language have essentially been resolved. Cells can be routinely grown in test tubes by tissue-culture techniques. The exact biochemical mechanisms of many hereditary disorders have been clarified. Computer programs for genetic analysis are in common use. All these advances and many others have inevitably led to discussions and suggestions for the modification of human heredity, both in individuals and in populations: genetic engineering.

One of the principal concerns of the pioneers in the field is the problem of the human genetic load, that is, the frequency of disadvantageous genes in the population. Each of us carries between three and eight genes that, if present in double dose in the offspring of two carriers of identical genes, would lead to severe genetic abnormality, or even to death of the affected individual before or after birth. In view of the rapid medical advances in the treatment of such diseases, it is likely that affected individuals will be able to reproduce more frequently than in the past. Therefore, instead of a loss of genes due to death or sterility of the abnormal, the mutant gene will be transmitted to future generations in a slowly but steadily increasing frequency. This is leading the pessimists to predict that we will become a race of genetic cripples requiring a host of therapeutic crutches. The optimists, on the other hand, have a great faith that the forces of natural evolution will continue to select favorably those individuals who are best adapted to the then current environment. It is important to remember in this context that the "natural" environment necessarily includes man-made medical, technical, and social factors.

Because it appears that at least some of the aspects of evolution and a great deal of genetic planning will be in human and, specifically, scientific hands, it is crucial at this relatively early stage to consider the ethical implications of these proposed maneuvers. Few scientists today doubt the feasibility of genetic engineering, and there is considerable danger that common use of this practice will be upon us before its ethical applications are defined.

A number of different methods have been proposed for the control and modification of human hereditary material. Some of these methods are meant to work on the population level, some on the family level, and others directly on the affected individual. Interest in the alteration of the genetic pool of human populations originated shortly after the time of Mendel and Darwin, in the latter part of the 19th century. The leaders were the English group of

* Based on a paper originally given at a symposium jointly sponsored by Marymount College, N.Y., and Commonweal Magazine. Reprinted by permission from Commonweal 88: 257–261 (1968), 232 Madison Ave., New York, N.Y.

eugenicists headed by Galton. Eugenics is nothing more than planned breeding. This technique, of course, has been successfully used in the development of hybrid breeds of cattle, corn, and other food products.

Human eugenics can be positive or negative. Positive eugenics is the preferential breeding of so-called superior individuals in order to improve the genetic stock of the human race. The most famous of the many proponents of positive eugenics was the late Nobel Prize winner Herman J. Muller. He suggested that sperm banks be established for a relatively small number of donors, chosen by some appropriate panel, and that this frozen sperm remain in storage until some future panel had decided that the chosen donors truly represented desirable genetic studs. If the decision is favorable, a relatively large number of women would be inseminated with these samples of sperm; proponents of this method hope that a better world would result. The qualifications for such a donor would include high intellectual achievement and a socially desirable personality, qualities assumed to be affected by the genetic make-up of the individual, as well as an absence of obvious genetically determined physical anomalies.

A much more common effort is in the application of negative eugenics. This is defined as the discouragement or the legal prohibition of reproduction by individuals carrying genes leading to disease or disability. This can be achieved by genetic counseling or by sterilization, either voluntary or enforced. There are, however, quite divergent opinions as to which genetic traits are to be considered sufficiently disadvantageous to warrant the application of negative eugenics.

A diametrically opposite solution is that of euthenics, which is a modification of the environment in such a way as to allow the genetically abnormal individual to develop normally and to live a relatively normal life. Euthenics can be applied both medically and socially. The prescription of glasses for nearsighted individuals is an example of medical euthenics. Special schools for the deaf, a great proportion of whom are genetically abnormal, is an example of social euthenics. The humanitarianism of such efforts is obvious, but it is exactly these types of activities that have led to the concern of the pessimists, who assume that evolution has selected for the best of possible variations in man and that further accumulations of genes considered abnormal can only lead to decline.

One of the most talked-about advances for the future is the possibility of altering an individual's genetic complement. Since we are well on the way to understanding the genetic code, as well as to deciphering it, it is suggested that we can alter it. This code is written in a language of 64 letters, each one determined by a special arrangement of three out of four possible nucleotide bases. A chain of these bases is called deoxyribonucleic acid, or DNA, and makes up the genetic material of the chromosomes. If the altered letter responsible for an abnormal gene can be located and the appropriate nucleotide base substituted, the corrected message would again produce its normal product, which would be either a structurally or enzymologically functional protein.

Another method of providing a proper gene, or code word, to an individual having a defect has been suggested from an analysis of viral behavior in bacteria. It has long been known that certain types of viruses can carry genetic information from one bacterium to another or instruct a bacterium carrying it to produce what is essentially a viral product. Viruses are functional only when they live in a host cell. They use the host's genetic machinery to translate their own genetic codes. Viruses living parasitically in human cells can cause such diseases as poliomyelitis and have been implicated in the causation of tumors. Other viruses have been shown to live in cells and to be reproduced along with the cells without causing damage either to the cell or to the organism. If such a harmless virus either produces a protein that will serve the function of one lacking in an affected individual, or if it can be made to carry the genetic material required for such functions into the cells of the affected individual, it could permanently cure the disease without additional therapy. If carried on to the next generation, it could even prevent the inheritance of the disease.

Transplanting Nuclei

An even more radical approach has been outlined by Lederberg. It has become possible to transplant whole nuclei, the structures that carry the DNA, from one cell to another. It has become easy to grow cells from various tissues of any individual in tissue culture. Such tissue cultures can be examined for a variety of genetic markers and thereby screened for evidence of new mutations. Lederberg suggests that it would be possible to use nuclei from such cells derived from known human individuals, again with favorable genetic traits, for the asexual human reproduction of replicas of the individuals whose nuclei are being used. For example, a nucleus from a cell of the chosen individual could be transplanted into a human egg whose own nucleus has been removed. This egg, implanted in a womb, could then divide just like a normal fertilized egg, to produce an individual genetically identical to the one whose nucleus was used. One of the proposed advantages of such a method would be that, as in positive eugenics, one could choose the traits that appear to be favorable, and do so with greater efficiency by eliminating the somewhat randomly chosen female parent necessary for the sperm bank approach. Another advantage is that one can mimic what has developed in plants as a system for the preservation of genetic stability over limited periods of time. Many plants reproduce intermittently by such vegetative or parthenogenetic mechanisms, always followed by periods of sexual reproduction for the purpose of elimination of disadvantageous mutants and increase in variability.

Another possibility derives from two other technological advances. Tissue typing, similar to blood typing, has made it possible to transplant cells, tissues, and organs from one individual to another with reasonably long-term success. During the past few years, scientists have also succeeded in producing cell hybrids containing some of the genetic material from each of two cell types, either from two different species or from two different individuals of the same species. Very recently, Weiss and Green at New York University have succeeded in hybridizing normal human culture cells with cells from a long-established mouse tissue-culture line. Different products from such fusions contain varying numbers of human chromosomes and, therefore, varying amounts of human genes. If such hybrids can be produced which carry primarily that genetic information which is lacking or abnormal in an affected individual, transplantation of these cultured cells into the individual may produce a correction of his defect.

These are the proposed methods. It is now fair to consider the question of feasibility. Feasibility must be considered not only from a technical point of view; of equal importance is the effect of each of these methods on the evolution of the human population and the effect of evolution on the efficacy of the method. In general, it can be stated that most of the proposed methods either now or in the not too distant future will be technically possible. We are, therefore, not dealing with hypothesis in science fiction but with scientific reality. Let us consider each of the propositions independently.

Positive eugenics by means of artificial insemination from sperm banks has been practiced successfully in cattle for years. Artificial insemination in man is an everyday occurrence. But what are some of its effects? There is now ample evidence in many species, including man, of the advantages for the population of individual genetic variation, mainly in terms of flexibility of adaptation to a changing environment. Changes in environment can produce drastic effects on some individuals, but a population that contains many genetic variations of that set of genes affected by the particular environmental change will contain numerous individuals who can adapt. There is also good evidence that individuals who carry two different forms of the same gene, that is, are heterozygous, appear to have an advantage. This is true even if the gene in double dose—that is, in the homozygous state—produces a severe disease. For example, individuals homozygous for the gene coding for sickle cell hemoglobin invariably develop sickle cell anemia, which is generally fatal before the reproductive years. Heterozygotes for the gene are, however, protected more than normals from the effects of the most malignant form of malaria. It has been shown that women who carry the gene in single dose have a higher fertility in malarial areas than do normals. This effect is well known to agricultural geneticists and is referred to as hybrid vigor. Fertilization of many women by sperm from few men will have an adverse effect on both of these advantages of genetic variability because the population will tend to be more and more alike in its genetic characteristics. Also, selection for a few genetically advantageous factors will carry with it selection for a host of other genes present in the same individuals, genes whose effects are unknown when present in high numbers in the population. Therefore, the interaction between positive eugenics and evolution makes this method not feasible on its own.

Abnormal Offspring

Negative eugenics is, of course, currently practiced by most human geneticists. It is possible to detect carriers of many genes that, when inherited from both parents, will produce abnormal offspring. Parents, both of whom carry such a gene, can be told that they have a one-in-four chance of producing an abnormal child. Individuals who carry chromosomal translocations are informed that they have a high risk of producing offspring with congenital malformations and mental retardation. But how far can one carry out such a program? Some states have laws prescribing the sterilization of individuals mentally retarded to a certain degree. These laws are frequently based on false information regarding the heredity of the conditions. The marriage of people with reduced intelligence is forbidden in some localities, again without adequate genetic information. While the effects of negative eugenics may be

quite desirable in individual families with a high risk of known hereditary diseases, it is important to examine its effects on the general population.

These effects must be looked at individually for conditions determined by genes that express themselves in a single dose (dominant) or in double dose (recessive) and those which are due to an interaction of many genes (polygenic inheritance). With a few exceptions, dominant diseases are rare and interfere severely with reproductive ability. They are generally maintained in the population by new mutations. Therefore, there is either no need or essentially no need for discouraging these individuals from reproduction. Any discouragement, if applicable, will be useful only within that family but not have any significance for the general population. One possible exception is the severe neurological disorder, Huntington's chorea, which does not express itself until most of the patient's children are already born. In such a situation it may be useful to advise the child of an affected individual that he has a 50% chance of developing the disease and a 25% chance of any of his children's being affected. Negative eugenics in such a case would at least keep the gene frequency at the level usually maintained by new mutations.

The story is quite different for recessive conditions. Although detection of the clinically normal carriers of these genes is currently possible only for a few diseases, the techniques are rapidly developing whereby many of these conditions can be diagnosed even if the gene is present only in single dose and will not cause the disease. Again, with any particular married couple it would be possible to advise them that they are both carriers of the gene and that any child of theirs would have a 25% chance of being affected. However, any attempt to decrease the gene frequency of these common genetic disorders in the population by prevention of fertility of all carriers would be doomed to failure. First, we all carry between three and eight of these genes in single doses. Secondly, for many of these conditions, the frequency in the population of carriers is about one in 50 or even greater. Prevention of fertility for even one of these disorders would stop a sizable proportion of the population from reproducing and for all of these disorders would prevent the entire human population from having any children. Reduction in fertility of a sizable proportion of the population would also prevent the passing on to future generations of a great number of favorable genes and would, therefore, interfere with the selective aspects of evolution, which can function only to improve the population within a changing environment by selecting from a gene pool containing enormous variability. It has now been shown that in fact no two individuals, with the exception of identical twins, are likely to be genetically and biochemically identical, thereby allowing the greatest possible adaptation to changing environment and the most efficient selection of the fittest.

The most complex problem is that of negative eugenics for traits determined by polygenic inheritance. Characteristics inherited in this manner include many measurements that are distributed over a wide range throughout the population, such as height, birth weight, and intelligence. The last of these can serve as a good example of the problems encountered. Severe mental retardation in a child is not infrequently associated with perfectly normal intelligence or in some cases even superior intelligence in the parents. These cases can, *a priori*, be assumed to be due to the homozygous state in the child of a gene leading to mental retardation, the parents representing heterozygous carriers. On the other hand, borderline mental retardation shows a

high association with subnormal intelligence in other family members. This type of deficiency can be assumed to be due to polygenic factors, more of the pertinent genes in these families being of the variety that tends to lower intelligence. However, among the offspring of these families there is also a high proportion of individuals with normal intelligence and a sprinkling of individuals with superior intelligence.

All of these comments are made with the realization that our current measurements of intelligence are very crude and cannot be compared between different population groups. It is estimated that, on the whole, people with superior intelligence have fewer offspring than do those of average or somewhat below average intelligence. If people of normal intelligence were restricted to producing only two offspring and people of reduced intelligence were by negative eugenics prevented from having any offspring at all, the result, as has been calculated by the British geneticist Lionel Penrose, would be a gradual shift downward in the mean intelligence level of the population. This is due to the lack of replacement of intellectually superior individuals from offspring of the majority of the population, that is, those not superior in intellect.

Current Possibilities

It can be seen, therefore, that neither positive nor negative eugenics can ever significantly improve the gene pool of the population and simultaneously allow for adequate evolutionary improvement of the human race. The only useful aspect of negative eugenics is in individual counseling of specific families in order to prevent some of the births of abnormal individuals. One recent advance in this sphere has important implications from both a genetic and a social point of view. It is now possible to diagnose genetic and chromosomal abnormalities in an unborn child by obtaining cells from the amniotic fluid in which the child lives in the mother. Although the future may bring further advances, allowing one to start treatment on the unborn child and to produce a functionally normal infant, the only currently possible solution is restricted to termination of particular pregnancies by therapeutic abortion. This is, of course, applied negative eugenics in its most extreme form.

Euthenics, the alteration of the environment to allow aberrant individuals to develop normally and to lead a normal life, is currently being employed. Medical examples include special diets for children with a variety of inborn errors of metabolism who would, in the absence of such diets, either die or grow up mentally retarded. Such action, of course, requires very early diagnosis of these diseases, and programs are currently in effect to routinely examine newborns for such defects. Other examples include the treatment of diabetics with insulin and the provision of special devices for children with skeletal deformities. Social measures are of extreme importance in this regard. As has many times been pointed out by Dobzhansky, it is useless to plan for any type of genetic improvement if we do not provide an environment within which an individual can best use his strong qualities and obtain support for his weak qualities. One need only mention the availability of an environment conducive to artistic endeavor for Toulouse-Lautrec, who was deformed by an inherited disease.

The feasibility of alteration of an individual's genes by direct chemical change of his DNA is technically an enormously difficult task. Even if it became possible to do this, the chance of error would be enormous. Such an error, of course, would have the diametrically opposite effect of that desired; in other words, the individual would become even more abnormal. The introduction of corrective genetic material by viruses or transplantation or appropriately hybridized cells is technically predictable and, since it would be performed only in a single affected individual, would have no direct effect on the population. If it became widespread, it could, like euthenics, increase the frequency in the population of so-called abnormal genes, but if this treatment became a routine phenomenon, it would not develop into an evolutionarily disadvantageous situation. It must also be constantly kept in mind that medical advances are occurring at a much more rapid rate than any conceivable deterioration of the genetic endowment of man. It is, therefore, very likely that such corrective procedures will become commonplace long before there is a noticeable increase in the load of disadvantageous genes in the population.

The growing of human beings from cultured cells, while again possibly feasible, would interfere with the action of evolutionary forces. There would be an increase, just as with positive eugenics, of a number of individuals who would be alike in their genetic complement, with no opportunity for the high degree of genetic recombination that occurs during the formation of sperm and eggs and which is evident in the resultant progeny. This would diminish the adaptability of the population to changes in the environment and, if these genetic replicas were later permitted to return to sexual reproduction, would lead to a marked increase in homozygosity for a number of genes with the disadvantages pointed out before.

Who Will Be the Judges?

We see, therefore, that many of the proposed techniques are feasible although not necessarily practical in producing their desired results. We may now ask the question, which of these are ethical from a humanistic point of view? Both positive and negative eugenics as applied to populations presume a judgment of what is genetically good and what is bad. Who will be the judges, and where will the line be between good and bad? We have had at least one example of a sad experience with eugenics in Nazi Germany. This alone can serve as a lesson on the impossibility of separating science and politics. The most difficult decisions will come in defining the borderline cases. Will we breed against tallness because space requirements become more critical? Will we breed against nearsightedness because people with glasses may not make good astronauts? Will we forbid intellectually inferior individuals from procreating despite their proved ability to produce a number of superior individuals? Or should we, rather, provide an adequate environment for the offspring of such individuals to realize their full genetic potential?

C. C. Li, in his presidential address to the American Society of Human Genetics in 1960, pointed out the real fallacy in eugenic arguments. Man has continuously improved his environment to allow so-called inferior individuals to survive and reproduce. The movement into the cave and the

putting on of clothes protected the individual unable to survive the stress of the elements. Should we then consider that we have reached the peak of man's progress, largely determined by environmental improvements designed to increase fertility and longevity, and that any future improvements designed to permit anyone to live a normal life will only lead to deterioration? Nineteenth-century scientists, including such eminent biologists as Galton, firmly believed that this peak was reached in their time. This obviously fallacious reasoning must not allow a lapse in ethical considerations on the part of the individual and by humanity as a whole, just to placate the genetic pessimists.

The tired axiom of democracy that all men are created equal must not be considered from the geneticist's point of view, since genetically all men are created unequal. Equality must be defined purely and simply as equality of opportunity to do what one is best equipped to do. When we achieve this, the forces of natural evolution will choose those individuals best adapted to this egalitarian environment. No matter how we change the genetic make-up of individuals, we cannot do away with natural selection. We must always remember that natural selection is determined by a combination of truly natural events and the artificial modifications that we are introducing into our environment in an exponentially increasing number.

With these points in mind, we can try to decide what, in all of these methods, is both feasible and ethical. I believe that the only logical conclusion is that all maneuvers of genetic engineering must be judged for each individual and in each case must take into primary consideration the rights of the individual. This is by definition impossible in any attempt at positive eugenics. Negative eugenics in the form of intelligent genetic counseling is the answer for some. Our currently unreasonable attitude toward practicing negative eugenics by means of intelligent selection for therapeutic abortion must be changed. Basic to such a change is a more accurate definition of a living human being. Such restricted uses of negative eugenics will prevent individual tragedies. Correction of unprevented genetic disease, or that due to new mutation, by introduction of new genetic material may be one answer for the future; but until such a new world becomes universally feasible, we must on the whole restrict ourselves to environmental manipulations from the points of view both of allowing affected individuals to live normally and of permitting each individual to realize his full genetic potential. There is no question that genetic engineering will come about. But both the scientists directly involved and, perhaps more important, the political and social leaders of our civilization must exercise utmost caution in order to prevent genetic, evolutionary, and social tragedies.

* * *

WADDINGTON: I wanted to make some general remarks about biology, but first I would like to make one or two comments on Dr. Hirschhorn's statement. I think the possibilities of biological engineering, particularly of the kind he talked about, sound very much like science fiction. But you are not necessarily very far away from practical solution. Let us say they are not far away if anyone is prepared to spend the money to develop them. It seems that nuclear transportation is extremely easy, and we can clone frogs, we can transplant nuclei from one egg into another, and we can do much more radical things than merely cloning individuals. It is quite possible to

make hybrid cells by somatic cell fusion. Grow cells in culture, particularly in the presence of a certain killed virus, and they very often stick together though they are somewhat unstable in their behavior at the division.

And you can select out from such a culture nuclei that have different combinations of chromosomes from different species. Such nuclei have been made. There are hybrid cells, hybrid between man and mouse. Nobody has ever yet injected such a nucleus into an egg capable of developing. The thing has not yet been done in frogs, but it could be done tomorrow, making transplantation between hybrid and toad chromosomes into a frog. It cannot yet be done in mammals, but people are working on developing methods of transplanting nuclei into the mammal—which is, of course, much more difficult to handle. But it is perfectly possible to do.

But to make it a practical proposition that could be relied on would cost quite a lot. It would not cost as much as developing the atom bomb, but it is not the sort of thing that can be developed in secret without everybody's knowing about it. It will be developed only if the taxpayer agrees to foot the bill. But I think it is a definite question of whether such types of work will be developed, and for what purpose.

I think it is most likely that in the next ten or 20 years such hybridization will be developed in order to produce better domestic animals for, say, tropical Africa. Plant breeders have, for decades, put disease resistance from a wild species of potato into cultivated potatoes by arranging to transfer the chromosome. Animal breeders have not been able to do this in the past, but they will be able to in about ten or 15 years if they want to. And I think it is quite likely they will want to for breeding really suitable animals for domestic life in the infested parts of Africa. Once this has been done in cattle, it can be done in other species of animals, and people will have to think whether they want it done with hominoids and themselves.

Having said that in relation to Dr. Hirschhorn's paper, I would like to make some remarks on my own. I would like to make a theoretical, almost philosophical, point.

Civilization as we know it in recent years has been based on and dominated by physical-chemical methods. We are essentially a mechanically based civilization. I think the major problems in the world today and the immediate future are really much more biological than they are physical and chemical.

It is physically impossible for the whole world to become developed in the sense of the highly industrialized developed nations of the West today. There simply are not enough raw materials of various kinds to go around. Each American is supported, I believe, by the order of a thousand tons of steel and several tons of aluminum, titanium, all sorts of minerals. It has been calculated that, to provide everyone in the world with a four-sheet daily newspaper and four sheets of toilet paper would require production of all the forests in the world to be multiplied by four times. I think there is no practical possibility of the whole world's developing into our present kind of quick-turnover, usually wasteful type of civilization.

If the world is going to develop, it must develop into something based on long lifetimes of artifacts that either last for a very long time or, when used up, are recycled. That is much more the kind of thing we find in biology. In physical systems, one is usually analyzing systems with a relatively small number of components, and one is usually interested in

maximizing the output or turnover rate of one of the components. Biological systems normally involve very large numbers of components, and the only thing one thinks of in the way of maximizing is maximizing from extremely complex function of all the components. The only thing biology really maximizes is this peculiar index called evolutionary fitness, and this is such a complex concept that nobody, in my opinion, ever really satisfactorily defines what it means. It is a component something like the value of a hand of cards that become bridge. It is a capacity to cope with whatever may turn up over the next few years. It is highly complex, but it is the only thing that goes in for maximizing.

Everything else goes into optimizing, and I think this is a totally different type of outlook, one much more appropriate to the kinds of work we are going into. We have to be able to think up systems in which all the components are optimized in relation to some global, overall, end product that is, as I say, the function of a vast number of variables. Take, for instance, the agricultural revolution. A whole of civilization has been based on artificial landscapes, artificial landscapes that are really types of agriculture. They may be the European open-field systems, or the development of enclosed fields with rotation of crops, or terraced rice fields in the East, etc., but they are all artificial, man-made, functioning ecosies. But the basis of civilization was laid in systems that were relatively self-stabilizing.

Now we have based agriculture on monocultures, maximizing some things, such as the output of wheat—maximizing it by putting in vast amounts of fertilizers, playing with the risk of a new pest from which the crop is completely unprotected—and we are gambling on some unstable non-self-stabilizing ecosies.

I think we are going to have to try to think of designing self-stabilizing ecological systems, and I think this is one of the great challenges to biology; what do you do with the great masses of bush in Africa? We simply do not know how to turn those things into productive, self-stabilizing, new forms of landscape suitable for civilized life. Europe has done it, China has done it, India perhaps did it for a bit, but there are vast areas of the world where this re-creation of true nature into a man-adapted nature has not been done. And I believe this is really much more challenging and ultimately much more immediate than the problem of environmental pollution that we, in the West, are so excited about at the moment. In point of fact, the major thing we have done to our environment in the last 50 years is to clean it up. We have cleaned it up biologically. We have got rid of yellow fever, the plague, most of the intestinal parasites, the nematodes, what have you. Our environment is much cleaner than it was a hundred years ago or than it is now in India and Africa.

The particular types of pollution we are putting into it now are, of course, very sinister and certainly have to be controlled. But on a world scale, this is somewhat second-order, and if you walk through the cities of Bombay or Calcutta you are not really likely to think that New York is a lot dirtier. I'm afraid you will find they are a lot dirtier than New York. But they are dirty not only with industrial pollutants but also with biological pollutants of disease, etc. And I feel the great problem for the world as a whole and for 80 percent of the developing world is first to clean it up biologically and second to design new, self-stabilizing functional ecosystems that produce the agriculturally useful crops we have.

BRONK: And now, Dr. Hedén.

POTENTIAL OF APPLIED MICROBIOLOGY

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Before man learned to use fire, he probably found that seed grains left soaking in rain water would turn into a stimulating brew. Small chisel blows of trial and error slowly shaped a range of primitive fermentations that preserved perishable foods and improved their taste, texture, and nutritive value. We now know that those processes are based on activities linked to a microcosm of unicellular organisms that always surround us, fighting a constant battle with each other and with the higher plants and animals. The importance of this invisible world is indicated by the fact that the upper few centimeters of any well-cultivated soil contains some 300–3,000 kilograms of living microorganisms per hectare. Many of these microorganisms we are able to classify only in general terms; some we cannot even cultivate. Lacking automatic screening devices, we must resort to guesswork about such important matters as the ecological effects of herbicides, pesticides, etc., but this will certainly change as a consequence of recent advances in numerical taxonomy. We will then have tools that will be very powerful for turning microbial ecology to our benefit.

Living beings not only have developed defense mechanisms adapted to their normal environment but also have often learned to derive benefits from other organisms that fit into the same ecological niche. Man, who has developed highly advanced protective mechanisms, has not only been able to expand his niche by countering the defenses of other organisms; he has also learned to exploit other living systems in a conscious and systematic fashion. Microbiology concerns itself with both aspects: the neutralization of pathogens (by vaccines, chemotherapeutic agents, interferon inducers, sera, etc.) and the use of selected strains to yield valuable products (amino acids or vitamins) or perform desirable conversions (steroid synthesis, mineral leaching, etc.). Sometimes—as with most antibiotics—the product we seek is part of the armory a microorganism has developed to guard against competition in a mixed population. We select the organism on the basis of certain desired features, then grow it without imposing the stresses of its normal environment (semistarvation and a temperature that is just as suboptimal as the dissolved-oxygen concentrations it has to put up with in nature). This means that we may well prevent derepression of potentially important genetic sites, but our technique also excludes from consideration products that require cooperation between several different types of microorganisms. Because symbiosis is so often observed in nature, it would be logical to think that cooperation in building barriers around common ecological niches would be fairly common.

Obviously then there is much to be said for systematic studies of "synthetic" mixed populations, especially now that continuous-culture methods have given us such a versatile tool. It is now possible to study the competitive forces regulating the carbon and nitrogen cycles in nature, as well as to begin development of an automated optimization of microbiological production processes.

Until now, applied microbial ecology (wine, beer, cheese, sauerkraut, vinegar, and Oriental fermented foods) has gone its own empirical way, unaffected by the remarkable developments in microbial physiology and genetics. This will certainly change, and we will probably devote much attention to symbiotic fermentations. One interesting example has been provided by M. Tveit and co-workers, who grew a fodder yeast (*Torula*) on waste starch partially decomposed by a mold (*Endomycopsis*). And V. R. Srinivasan demonstrated the decomposition of cellulose by one bacterium (*Cellulomonas*), assisted by another (*Alcaligenes faecalis*) that has the capacity to eliminate a primary breakdown product (cellobiose) that would otherwise arrest the breakdown.

Such efforts are important, because we are now starting to touch uncomfortably many of the walls around our ecological niche. One wall is in outer space, where the astronauts may be exposed to a new size range of infectious particles floating about them, and where they may also risk loss of some of the protection afforded by the normal flora they carry along from earth. Such a mixed crowd of "stowaways" could include pathogens, and these might well play havoc with the crew of an orbiting laboratory or a planetary base. The orbiting personnel might previously have been shielded from the subclinical minor infections that stimulate our defensive mechanisms here on Earth. Obviously, microbial ecology could become a critically important feature of health surveillance in space, but in a more distant future, the well-being of certain microorganisms could well become the second most important consideration. This would, for example, be true if it were decided to use microbiological gas exchangers (algae or *Hydrogenomonas*) for controlling the atmospheres in confined spaces.

Space research offers a dramatic reminder that man depends on his microbiological environment, but our ignorance is disturbingly great. For instance, the intestinal flora with which we live in balance provides us with valuable vitamins (K and the B group), but the details of what it does to our food are largely unknown. However, we know that aromatization of certain organic compounds by the intestinal flora may yield harmful products and that many anaerobes produce potent toxins. One cannot help wondering what inoculation at birth with a cocktail of proved beneficial strains could mean to health and aging. In particular, one wonders if it would not be possible to establish some strains with a potent nitrogen-fixing ability or with defective regulatory genes in order to yield essential amino acids that might supplement a deficient dietary protein later in life. Maintenance of the "artificial" flora would probably require occasional reinoculation and, possibly, some adjustment of food habits, but it would be worth the trouble. Under all circumstances, it might become an established practice to deposit one's normal flora, as well as germ cells and bone marrow, in deep-freeze storage. This might be considered reasonable preparation for later exposures to broad-spectrum antibiotics, radiation, or leukemia (virus?).

Space research may remind us of ecological walls, but it is, of course, here on earth that the walls are closing in on us. The planet is getting crowded and full of biologically significant stresses, increasing the probability of infectious disease here, no less than in the confined space cabin. Again, the normal flora is jeopardized: by indiscriminate use of antibiotics in medicine, by chemicals in industry and agriculture, by widespread cleaning and disinfecting compounds in the household. The consequences, for instance in the form of disturbed mineralization processes, are now so common that we take them for granted and forget that applied microbiology can offer many remedies.

Let us first consider the microbiological implications of increased population density, which go far beyond influences on the epidemiology of infectious disease. There is, for instance, a need to increase food production drastically if predictions of serious famines are not to come true. Here, the first microbiological priority should be concerned with the reduction of waste (fermentative preservation techniques and control of toxigenic fungi and bacteria). Second in importance is an expansion of the traditional animal protein resources (fortification of animal fodder by yeast grown on hydrocarbons or sulfite liquor or by algae grown on sewage; extended conversion of cellulose waste to meat by use of microorganisms that operate inside the herbivores; veterinary vaccines against rinderpest, foot-and-mouth disease, and Newcastle virus; aerosol vaccination, etc.) and of the normal agricultural crops. An important aspect of the latter has been referred to as "the green revolution"—expanding monocultures of high-yielding plant varieties grown under a chemical umbrella of insecticides. The microbiologist should be aware that the latter may become increasingly unattractive as environmental concern spreads from the industrialized nations to the developing countries of the world. Because breeding of insect-resistant plant varieties is a time-consuming affair, microbiology should focus attention on biological control by insect pathogens. An example of the current interest in this area of study is the recent establishment by a number of academies of an entomological field station in Nairobi. It is fairly safe to predict that biological control will become an important activity and that it will be greatly accelerated by recent advances in aerobiology. The relation between particle size and penetration of a jungle canopy has for instance, been established, and microencapsulation has provided new possibilities to protect bacteria and viruses suspended in the air. In addition, insect tissue-cell culture may lead to novel production techniques.

The "green revolution's" requirements for water and for nitrogen fertilizers (as much as 100 kilograms per hectare) give the applied microbiologist additional food for thought. Nitrogen fertilizers already ensure the existence of one-sixth of the globe's population; by the turn of the century we must obviously produce some 50 million tons per year, which may not appear to be very much when compared with the 100 million tons of nitrogen fixed by soil microorganisms, but it is still a lot to transport. Nitrogen is the major nutrient whose lack often limits plant development in many parts of the world, and India now uses one-fifth of its foreign exchange to buy fertilizers. Consequently, an extended use of blue-green algae, or bacteria that can utilize the nitrogen in the air, or plants (alfalfa, clover, soy) that can use microorganisms for the same purpose, seems essential. But the proper organisms for use as soil or seed inoculants must be found, and this still requires extensive investigation. Genetic research aimed at giving nitrogen-fixing ability to such common grains as wheat might also be undertaken, and many sectors of soil microbiology should be stimulated. There is every reason to believe, for example, that we can increase the economic return per kilogram of nitrogen fertilizer used in the field. This may actually be quite low in some areas because denitrifying bacteria

cause volatilization of the nitrogen that is applied to the soil or formed during ammonium oxidation. In other cases, the assimilation processes are so slow that inorganic nitrogen is washed out of the soil by percolating water before it can be used by plants. Knowledge about such processes, about the depression of biological nitrogen fixation by mineral fertilizers, and about the microbial production of substances that cement dust together to form aggregates that improve aeration and root development, more information about all these phenomena will certainly indicate solutions to many current problems. Our example of this is the mineralization process in waste treatment, which becomes more and more important as the recirculation concept becomes the central theme in pollution control. Waste will come to be regarded as a resource rather than as a nuisance. As pointed out by J. W. M. La Rivière: "Molasses is an industrial waste in a country where there is no industry to use it, but it is a valuable raw material to a fermentation industry elsewhere. The designation 'waste' merely signifies a corresponding lack in our technological potential as expressed in a low price, which is negative when treatment is required."

All waste can be converted into fertilizer by anaerobic digestion, and since this process will handle cattle, bullock, and pig manure, chopped straw, sugar-cane trash, beet leaves, coffee pulp, and all other sorts of vegetable materials, it early attracted attention in agricultural communities. There, the main interest was in the combustible methane formed during the process, because the gas can be used for grain drying, for hothouse heating, and even as a tractor fuel. However, little attention has been given to methane's heat value for temperature control in auxiliary fermentations or to the carbon dioxide that is generated when it is burned. This gas could be used not only for increasing the productivity in hothouses but also for algal cultures (for instance *Spirulina platensis*, which has been used for food by the natives of Chad for generations). However, where the illumination available for photosynthesis is inadequate, it might be more economical to convert the methane directly into fodder (or possibly even food) by using microorganisms. As indicated by studies in my own laboratory, this is quite feasible, although we are currently using methanol as the carbon source. By novel catalytic techniques, this alcohol can be produced very cheaply from methane.

It is highly probable that such gas conversions will become most important if we are ever forced to turn waste into human food. After all, we can easily clean and pipe the gases to a separate installation, provided with its own salt supply and nitrogen-fixing facility. The use of microbial cells grown directly in sewage is not so attractive because of the toxic metal salts and other industrial pollutants that are difficult to eliminate.

Most waste materials, as well as hydrocarbons, can thus be converted into a homogeneous organic material with the aid of microorganisms. We first think of this conversion in terms of food and fodder, amino acids, and vitamins, but it might also constitute the starting point for an integrated biochemical industry. Either the functional characteristics of the original material (enzymatic activity or physicochemical properties) will attract attention or we will use it as a starting point for subsequent conversions that can yield specialized molecules. It is reasonable to assume that specialized media will be produced for submerged growth of plant tissue cells or perhaps even for the cultivation of human diploid cells. The

latter could serve not only as a substrate for virus vaccine production but also for making substances compatible with our body (growth hormone, fibrinolytic enzymes, interferon, or even genetic repair materials). However, even such foreign materials as bacterial enzymes will also assume great medical importance. They now provide tools for laboratory diagnosis and serve as digestive aids, but the work of Chang and his co-workers in Canada indicates a growing therapeutic significance. Urease and an ion exchanger were microencapsulated in a material that is permeable to urea but not to antibodies. The resulting powder was then enclosed in a small tube that could be attached to an extracorporeal shunt in uremic animals, which responded very favorably to the treatment.

The use of enzyme technology based on solid carriers will also influence that branch of bioengineering concerned with fermentation. It will, for instance, be feasible to increase the permeability of cells at one stage in a process by adding substances that can be easily removed in later stages. Add to this the potential of microbial genetics, for example, permitting the automatic selection of resistant strains that make "protected fermentations" possible, and it is no wonder that bioengineering is an active field at most universities. However, the advances in molecular biology and basic genetic research come faster than the applied sciences can keep up with, so special efforts are needed.

Fortunately, we have the facilities and the personnel available; obviously there is also some statesmanship required. I am thinking of President Nixon's unilateral renouncement of biological warfare. This constructive initiative has set the stage for a system of cooperating laboratories, and if there is a reasonable amount of reciprocity an International Organization for Applied Microbiology might well be created. It would certainly be an important step toward improving the human environment.

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STUART MUDD: As multicellular organisms, we live in an environment that literally swarms with unicellular forms of life. We are surrounded and we are immensely outnumbered, as metazoan organisms, by the microorganisms that are in our earth and water and air and in our total environment.

Dr. Waddington has indicated that our relation to microorganisms is twofold. In one respect, they are enormously important as allies, and this possibility for aid to us has been sketched by Professor Hedén, who is a world authority. It seems appropriate for me, if I may, to sketch the inimical aspects of microorganisms to human beings, that is to say, to sketch a little bit of host and parasite interaction in the infectious diseases and in the allied rejection of foreign tissue, as we see it in the present wave of organ transplants, skin grafts, and other aspects of rejection immunology.

The beginning of adaptive immunity has been traced by Dr. Robert A. Good and Sir Macfarlane Burnet to the beginnings of vertebrate life. Up to this time the invertebrates got along quite well in the midst of their microbiological environment by mechanisms that are not well understood but did not involve what we now know as adaptive immunity.

In the last part of the 19th century, there was great debate as to whether the mechanisms of this adaptive resistance to the microorganisms that are a

threat to metazoan organisms was vested in the humors—that is the blood, the serum, the lymph—or in the cells. We had the great proponent of humoral immunity, Buchner of Germany, and the great proponent of cellular immunity, Metchnikoff of the Institut Pasteur. Like many controversies, it turned out that both sides had a great deal of truth in their positions, and it fell to Denys and Leclef in 1895 to show that, in the special case of streptococcal infection, the resistance was twofold: the infection gave rise to circulating antibodies, and these neutralized the toxins or attached themselves to the surface of the streptococci and caused them to be capable of being ingested and destroyed by the sentinel cells of the body. So this, in a sense, resolved the basic controversy. It resulted, however, in a concept that was incomplete with regard to the total mechanisms of interaction of host and parasite.

The great American microbiologist Theobald Smith has outlined the requisites of a successful parasite—that is, a parasite that is able to coexist in the presence of its host. He pointed out that the process of evolution in the host-parasite relationship was toward mutual tolerance. This is a very important point, I think, philosophically as well as biologically, because the successful evolution either of host or parasite is not in the destruction of the enemy but in an accommodation that makes it possible for the host and parasite to coexist in the same ecosystem. If the host is destroyed, that is the end of the road for the host, and if the parasite is destroyed, that is the end of the road for the parasite, but as they coexist in some of the older diseases, such as syphilis and tuberculosis, both can survive and multiply.

This subject has been studied in brilliant detail in regard to myxomatosis. This virus was introduced into Australia as a means of ridding the country of rabbits, which ate most of the grass needed for sheep pasturage. Fenner and Burnet introduced the Brazilian myxomatosis virus into Australian rabbits of European descent, and it has been found that Theobald Smith's prediction was actually realized. The initial virulent disease has given rise, in the course of time substantiated by individual investigators' studies, to a state where there is a reciprocal tolerance, and neither are the rabbits exterminated by the parasite nor vice versa, but by and large the two species survive in a state of tolerated coexistence.

The first 75 years, I would say, after the Denys and Leclef study, tended to indicate that the pattern that they developed, namely of circulating humoral components or antibodies that neutralized toxins or attached to the surface of the parasite and caused these parasites to be phagocytosed and killed, has stood up. But we have just had the privilege of submitting papers in which the situation has been amplified in regard to at least one pathogenic species, namely, *Staphylococcus aureus*.

It is found that in the special case of ordinary staphylococci, the action of the components of human serum in promoting phagocytosis and intracellular killing is not significantly improved by circulating antibodies. However, the bulwark of general bodily defense known as the reticuloendothelial system can be significantly augmented in its functioning by induction of hypersensitivity and elicitation of the activated state of defensive cells known as macrophages. This is cell-mediated resistance. Conditions for evoking this nonspecific cellular resistance may be rendered particularly favorable by the circumstance that most individuals are already hypersensitive to staphylococci, and elicitation of cell mediated resistance may be safely practiced with staphylococcal antigens. I believe it is not quixotic to hope that by such means we

may, in a measure, get the better of such infections as those that cause, for instance, the upper-respiratory infections, which exact such a heavy burden of suffering and reduced efficiency.

HOTCHKISS: When the higher organisms began to climb out of the ocean, they were taking some readings on the environment as it was then, and they developed means, with various pumps and pipes and strainers, to carry the atmosphere as they experienced it, so that they could pump the atmosphere and the various saline solutions they needed through their bodies. We can take, as a first approximation, what man needs even now by seeing what his various strainers are trying to filter out of the atmosphere and the very dilute saline that he takes in. Unfortunately, the niche that he was reaching for at that time was 20 percent of the planet's surface, and it seemed big enough. Now, of course, we are coming to the second approximation; the things that man filters out are becoming part of the environment themselves.

I think that man is a part of the environment and that he has taken his last evolutionary reading, at a time when the whole world was his and he could reach out for it all.

Dr. Hirschhorn has brought us very sharply up to date and reminded us that there are movements afoot that might change man's actual heredity.

I have the name for being involved simply because we take genes from one kind of bacteria and put them into another. This sort of genetic engineering is like robbing Peter to pay Paul, taking something already highly developed in one organism and transporting it into another. I do not actually consider this engineering, because the word engineering connotes, to me, some kind of concerted action operating on a more or less broad plane and actually this is one of the most intimate of all the things that man is trying to do.

The Shope papilloma virus, which is a dangerous enough thing for rabbits, forms the kind of arginase that seems to be characteristic of the virus. There are some questions about the details, but for a while, this was a cure looking for a disease. If anybody had too much arginine, this virus might be good for him. A couple of months ago, Stanfield Rogers told me that he discovered two siblings with a metabolic disease that indicated high arginine. The older child was in a very bad state; the younger child was going through the same premonitory symptoms and was simply at an earlier stage. These children have been given some of the virus to see if it will help. And this may be illustrative. I do not call this engineering, but genetic intervention. What sounds like science fiction is genetic manipulation, willful changing of properties that seem to be hereditary and, in higher organisms, are largely predetermined at a quite early age. One more of Dr. Hirschhorn's points is that what is ethical is anything that takes into account man's freedom of choice. I think it is important for all of us to realize that the very freedom of choice that has worked against eugenics was that we did not want to interfere with a person's right to choose another life partner because that was what one chose in genetics. The genes were carried by whole organisms and by whole nuclei from whole organisms.

Now we have the possibility before us, a very real one, that we can intervene with bits of gene fragments taken from anywhere. They are no longer stolen from Peter because they can be cultivated *in vitro*, and they were in a sense borrowed from Peter in order to enrich Paul. They are becoming more available all the time, and the freedom of choices we would be faced with is just the freedom between the right to take a small improvement and your

right to reject it or bypass the opportunity. So I think the very sentiment that made eugenics rather distasteful to most people is exactly the sentiment that makes these new things very tempting in the future.

UNIDENTIFIED DISCUSSANT: I would like to comment on Dr. Hirschhorn's definition of the ethical aspects of this, which I thought very brave of him, because we all know it is a very controversial issue. If we define the ethical aspects exclusively in terms of the free choice of people, what are we to say of generations in the future that are affected by our decisions now? I realize this is a very complicated question, but I merely throw it up for some discussion at some point in this conference, and I do not restrict that merely to genetic manipulation or engineering.

It seems to me that the people who will live after the year 2000 will have much less control over their presence than we today have over their presence. That is, the decisions we either make or do not make today will affect their lives in a greater dimension than they themselves will be able to affect their ilves. And if that is true, then the ethical aspect of that becomes exceptionally complicated, because we have no way of asking them what kind of world they want to live in, and most of us will not be around to live in it. But I do believe that this is an ethical question that goes beyond the concept of free choice of the people who are to participate in the consequences.

BRONK: This reminds me of a few years ago, when President Kennedy asked me to organize, from the National Academy, a study on our natural resources. After about eight or nine or ten months he asked how we were getting on, whether the 120-odd people who were studying the various aspects of the problems had come to any definitive position that he could use in any of his addresses. I told him it was too soon to have any very definite opinions. Then I suddenly thought and I said, "With one exception, Mr. President; I find that everybody is concerned about their own conditions and environment and availability for what they wish and need during their lifetime; almost everybody is concerned about the welfare of their children, practically everybody is concerned, to a certain degree, with the welfare of their grandchildren. But, Mr. President, I find in my discussions thus far that nobody gives a good Goddamn about their great-grandchildren's future." And I think this is one of our social problems, to be able to abrogate our own special private interests as of the moment, the immediate future, and look forward to the world and the conditions we are leaving for the others, including our biological environment.

UNIDENTIFIED DISCUSSANT: I think that the point that ethics is connected with the number of choices available is extremely important, and I think the point raised here should really be pursued. The interesting thing is that there is an answer to your question. The answer to the question of what decisions we have to make so that later generations may have their freedom of decision must be such that the number of decisions in later generations will be larger.

SAGER: I would like to focus not so much on what is possible in the future but on what is desirable, and, in fact, I have been anticipated, happily, by the last comments, which I welcome. We are all aware of the explosion of new knowledge in biological science and of the fact that this knowledge gives us a great range of possibilities for the future. And our problem is not so much to try to predict what will, in fact, happen, but rather to focus upon what we consider desirable, because it is only in that sense, I think, that we can have some influence on the future.

The comments that I am going to make stem from my experience in my own daily life. I am a research scientist, and, as such, I am impressed with the excitement and the fun of research in a laboratory as a way of life and also as a teacher. But I have discovered how difficult it is to communicate this excitement to my students.

First, I would stress what I consider to be the state of the art in biology at the moment, because I think this really sets the stage for our considerations, both realistic and idealistic. And I would like to stress in my view the outstanding achievement of biological research of the last 20 years—the establishment of molecular biology. Molecular biology tells us how cells work, and all future advances in basic and applied biology will rest on this solid framework. And I think one should not underestimate the power of what has been learned.

Already we see that the sudden burst of development of understanding in embryology and differentiation—to some extent in neurobiology and, hopefully, in the very complicated area of ecology—which is just beginning, will rest on this solid framework. The problems that we face, therefore, are not the problems of not having a solid framework on which to build research. Our problems are political problems.

Our problem is, first, will we live in a world affluent enough to support this basic research which will lead to a greater understanding of the natural world? Will we even live in a world able to afford the kinds of applied research that we will need so that we can solve the problems in order to do the basic research? And, perhaps most important, will there be any young people who want to do this research? Finally, as academic people and on the elderly side of this generation gap, where can we intercede in this problem?

In other words, what we have in our hands are powerful possibilities for good and powerful possibilities for evil. What I am going to propose is that we formulate a statement of a reordering of priorities in biological research. This reordering of priorities does not call for less research; it calls for more research, because a firm and continuing basic understanding of the fundamentals on which all of these applications are to be based is really just at the beginning. It would be a great error were one to say, we can stop doing basic research and apply some of this, because the applications have built into them the need for more knowledge. What we need is more, but we need a reordering of those priorities.

I would also like to propose an explicit ethical basis in the choice of research problems, in the choice of what one does and does not do. And finally, I would like to propose, in the panel discussion, a very preliminary and tentative biological bill of rights for man. Essentially this bill of rights deals with the rights of every individual to the kind of healthy and normal development that we would like to see for ourselves and for our children and for our friends.

And finally, I would like to stress that, as the health sciences, the biological sciences provide a new focus, a focus that I think we should take advantage of, because it is science that really focuses on the individual. All other areas of natural science can be thought of in very gross terms as dealing with sta-

tistics, people by the millions. As the planet becomes more crowded and as the problems become exacerbated, the importance of the individual and the dignity of the individual are bound to decline. One of the great contributions of emphasis on biology, I think, will be a reordering of our priorities to recognize and remember the importance of the health and dignity of the individual.

BRONK: I would like to endorse most heartily what Professor Sager has just said. Our problem now is not to find more money, not to find more appropriations, but to sensibly use what we have. And for that reason, our allocation of the primary priorities along specific narrow lines, whose effort can come to the most, will be the foremost thing that could be done.

SAGER: May I just say I am for more money for everybody.

BRONK: But I believe that before asking for more money we should make the best possible use of what we have. Relative to that, let me say that those who have been deeply involved in Washington for many, many years, had a very strong group of friends in Congress, people like Senator Lester Hill, Leverett Saltonstall, Warren Magnusen, Albert Thomas, and others. But times change, people die, some retire, many get defeated for re-election, and one of the great difficulties we have at the present time is that most of the people who are urging funds for support of research are engaged in this, and we are naturally suspect as having special interests. In this country—and I know England well enough to know the same applies there, and I know what goes on in Sweden—we do not have an adequate clientele willing to speak for what we think is important. Legislators and foundation executives have heard us say what we say many, many times. In industries that are dependent on the continued development of science, they speak very seldom on our behalf.

I remember several years ago when the National Science Foundation suddenly came up against a particular crisis and, in order to fulfill our obligations to universities, we wrote to about 20 university presidents and said, "Look, this is your problem as well as ours. We are trying to help you, you have a senator, you have two senators from your state, get busy." And within a couple of weeks the whole picture was changed.

So that we have, as Dr. Sager has said, to start with beginning education, develop a greater awareness of the role and the benefits as well as the handicaps and disadvantages of certain types of technology. We have to spread this more widely unless we are going to have a very different type of government than most of our countries have.

UNIDENTIFIED DISCUSSANT: I am just an observer from Sweden, but I would like to give a point of information on this. I have come from a conference on the future in Kyoto, Japan, and there was a most interesting paper from the University of Heidelberg. They had done opinion polls about research politics, and it was found, more or less irrespective of educational background, that they had a common framework about what was important, and that was in the biological sector and was, to a great extent, at odds with the actual politics of the German Government, which stressed nuclear research and military research.

HIRSCHHORN: In thinking about some of the comments that have been made about the question of ethics for future generations, I think we must be careful here to divide those aspects of individual freedom of choice which do not, in fact, affect the current individuals and those that do. For example, I

can very well agree with the comments that if we continue to allow complete individual freedom of choice of how many children every family is going to have, this may well have a strong detrimental affect on the biological environment of future generations.

On the other hand, because we have no concept at this time, in view of the rapidly changing environment—which, over the years becomes exponentially even greater—of what future adaptive values will be, we cannot sensibly plan a biology to adapt to an unknown environment. Nevertheless, we must strongly consider at this point that any of the genetic engineering type of changes not only will affect those future generations, but will, in fact, very strongly affect the individual on whom such manipulation is practiced.

UNIDENTIFIED DISCUSSANT: I work in environmental medicine, somewhat on the firing line because I am often called about people who have specific problems about environmental effects and human disease. And I was very unhappy to hear what Dr. Bronk said, because if it is true—and it may very well be—and if Dr. Sager's help is not realized for the future, I think we are in for a great deal of trouble.

I do not know whether even the scientific community is thoroughly aware of the very scant resources that our society in the United States and elsewhere is now applying to solutions of environmental problems. In this country, for example, this year's budget of the National Institute of Environmental Health Sciences, which is charged with all the basic research for the study of the biological effect of environmental changes in-house, extramural support, etc., is $18 million, and that is all. The other agency in our Government which has any relation to these problems, and which in the past had the major responsibility, is the Bureau of Occupational Safety and Health, and their budget this year for noise and accidental death and asbestos and carbon monoxide, etc., is $10 million for all research—their own, extramural, their administrative costs, etc. There is, for practical purposes, very little in the way of actual support, of putting our money where our discussions are, in this country. I don't think the situation is very much better in Great Britain, where there are some 14 research associations now looking at problems of water pollution, eight looking at problems of air pollution, and some at noise as well, and their total finances this year are two and-a-half million pounds, one and-a-half million for airport noise.

I would like to compound this pessimism by pointing out that the excellent discussion that we heard from Dr. Waddington and others really is almost like fighting the last war. The problems of the question of environmental changes are more complex than the microbiological approaches, which are basically a one-to-one relationship in many of these effects, whereas in environmental changes they are long-term, low-level, multiple-factor, and highly complex. The human effects are even more complex than this: they involve lifetimes, because most disease occurs in adults and their study requires detailed and long-term observation. Therefore, if we do not reorder our priorities in the sense, not of exchanging the funds that are now available for basic research for the long-term environmental research, but rather of a great extension of support available for environmental-factor research, we really are in for a great deal of trouble.

WOLF: I am the legal adviser of the International Labor Office. I was very much interested in what Dr. Ruth Sager had to say about the Bill of Rights,

and I am very happy she said it. Indeed, we have a Bill of Rights. We have a Bill of Rights on an international level, but what we need is more implementation of what exists. And it is possible.

In my organization, for instance, we started to protect the workers and indeed, all those who work, which is the whole world, against certain risks due to the environment. The predecessors of the ILO, just before the First World War, elaborated an international treaty against the use of white phosphorus. We have always continued in such fields, framing international treaties to protect the working man from all the dangers to which he is exposed. We were the first to lay down international regulations for the protection of ionizing radiation. And now we are preparing an international instrument on protection against benzine.

I think that through regulations on definite problems, a lot can be done to implement those rights you describe, Dr. Sager. The trouble is that we lawyers—and I think we are on equal footing with scientists and with politicians—despite all our efforts, lack imagination because we cannot foresee all the dangers. I will give you an example outside the sphere of the law of international regulation.

I live in Geneva, near the lake. Ten or 15 years ago, nobody thought that lake would be completely polluted, neither the lawyers nor the politicians nor the scientists. In a way I think the only human beings who had sufficient imagination to foresee this probably were the poets, because they are probably more sensitive to things than we are. But today that beautiful lake is completely polluted. I think a great effort has to be made by all of us to increase our imagination and to try to implement what we all believe.

WADDINGTON: I want to make one remark in relation to the last two speakers, and this is the question of some of the fundamental studies of environmental pollutants, and the low-level, long-term, toxic effects. This was quite a fashionable notion in the early days of nuclear bomb testing, when the public got very excited about the genetic hazards from ionizing radiation and fallout, and there was a strong movement to set up one large international laboratory under the auspices of the WHO to operate the facilities simply to test radiation damage alone. Of course, this is only one of the sort of low-level, long-term pollutants that emit thousands of substances about which we have no notion of what their long-term effects are going to be except that they are going to have long-term effects. It seems to me this is really too big a job probably even for the United States to take care of, particularly in its present situation. It is an eminently suitable job for international organizations because, unfortunately, much of this work boils down to pretty boring routine, and you are really going to have to test long-extended experiments at low levels. And it is a question of statistics' continuing to go up from the national level of one or two effects, and so on.

On the other hand, it could provide very good training grounds for countries whose scientific efforts are just getting off the ground and who are perhaps turning out more people capable of undertaking scientific research than they actually have facilities of their own to employ. I believe it is an extremely suitable subject to be organized by the international network of laboratories for testing environmental effects. And I believe that to work towards this is one of the things that an international meeting of this kind might endorse as a suitable policy.

BRONK: In regard to the moving remarks about Geneva, I am reminded of the fact, especially with regard to the esthetic environmen, that they are international. I believe I have a right to have the Lake of Geneva and the Baltic and the Highlands of Scotland preserved so that I can enjoy them as well as the Hudson River. And I think if we all had a greater awareness of a decent environment and a decent quality of life, we would have the sort of bill of rights that Ruth Sager has referred to, generally, rather than regionally, accepted. And that, perhaps, is relevant to an old German folk saying, if every man would clean his own doorstep, the whole world would be clean.

MOSS: I am somewhat concerned that the trend of fragmentation and specialization and superspecialization in the field of the medical sciences has caused the development of many deficits in our system of medical care. This is true not only in medicine but in other fields of science as well. And perhaps, as we give our concern to this topic, the potential solutions may evolve.

Alfred North Whitehead outlined three stages of progression in the educational process: the stage of romance, when knowledge is novel and exciting; the stage of specialization, when information and technique touch and test the intellect; and, finally, the stage of generalization, when freedom again dominates and the mind fuses culture with expertise. Few physicians attain this third plateau. Nine to 15 years of wearing academic blinders in our traditional undergraduate college, in medical school education, and in subsequent graduate training programs narrow the accepted definition of getting an education down to passing examinations, increasingly brief exposure to a greater number of departments and subdepartments, writing papers on increasingly fragmented subject matter, and becoming more vulnerable to specialization at earlier and earlier phases of the educational process. Concomitant with these developments has been the unabated progression of departmentalization into which the young trainees neatly fit and from which they rarely emerge to attempt assault on the third plateau of education.

All of this is adding to the crisis in American medicine and in the delivery of health care. The public is caught in a trap in this system, and perhaps this trend toward superspecialization over the past two decades has lent itself to some of the overt failures in our system to fill the void created. There is a long historical background as to how the specialization in various areas has tended to occur. Many contributions have been made, but I think that ultimately all of us will have to develop more interdisciplinary kinds of approaches to problems. We must somehow develop the capability for the broader sweep, we have in some way to provide teams of capable individuals so that they can provide a service to the public.

In medicine this may mean more emphasis on group practice; it may evolve in terms of our prepaid system of health care, it may mean that the emphasis in medical schools and in universities should be to reward those who have the capabilities and the contributions of the superb generalist rather than have smaller and smaller areas of knowledge being exploited. And perhaps each individual who makes such contributions in these specialized areas should not necessarily be the only one who can receive such rewards in the academic day-to-day competition.

We must have more synthesizers of some of the knowledge that is taking place in each of these fragmented areas. Unlike the emerging nations of Africa that so desperately need specialists in all fields of science and medicine, we in this country have successfully developed copious numbers of such specialists,

a multitude of analyzers in one field after another, penetrating into smaller and smaller crevices, and seeking finer and finer fragments of learning. We have to develop a more intensive training program for the kind of individual who has, perhaps, almost disappeared completely (he may not have disappeared completely, but his ranks have certainly thinned). We must create this kind of fine generalist in the image of a captain of a team, a strong and vigilant leader in intellectual insight and technical know-how in multiple fields. He must be able to overcome the Hippocratic aphorism that the art is getting longer and longer—with the art of the student not getting bigger and bigger.

The development of the team approach is beginning to gain some increasing acceptance, and even among physicians. Ten or 15 years ago there was a small but rather abortive attempt at this, but then it began to come into less accepted kinds of roles in most hospitals and in most medical centers around the country. There seems to be an aura of acceptance now, a general recognition that our pattern of medical care and health care is not necessarily the optimum that we thought it was and that our delivery system must be further streamlined and improved.

This, then, leads to the increasing emphasis that preventive approaches to health care are an area for the future that must be supported both financially and professionally and that will allow us to treat early-stage diseases with rather greater effect than we now achieve in the treatment of late disease. Certainly in the field of cancer, which is an area of special interest for me, the results, the end results of therapy over the last 30 years, have demonstrated that from 1940 to 1955 we made a dramatic improvement in the overall five-year survival results for major sites of cancer.

But since 1955 there has been a plateauing effect, so that very, very little improvement has occurred in the last 15-year period, with one major exception, and that has to do with carcinoma of the cervix, where there has been significant improvement on the basis of the contribution of the Papanicolaou smear. It is the effort of developing much more emphasis on preventive and early diagnostic tests that may perhaps lead us to the early-stage disease treatment to which we must devote our efforts. And the theme of many of the younger medical students and younger faculty members indicates this as a major objective in our overall medical care system.

BRONK: There is an old aphorism that scientists should know something about everything and everything about something, but the first part seems to be so often forgotten. The academic world, which should be the home of those who are at the frontiers of knowledge, should be concerned not, God forbid, with relevance but with the relations between one field and another. If I may be forgiven a personal experience, after three years in graduate work in physics I decided I wished to become a physiologist, but I also wanted to continue some of the work I had done in physics. So I finally got permission from the executive committee of the graduate school of the University of Michigan to take my degree in both. When, after what seemed to me a lot of hard work, I passed my final examination, I went to the office of the Dean of the Graduate School and saw my friend Ruth Rauss, and said, "Ruth, I'm all finished, it's done." She said, "Have you finally decided in what department you want to take your degree?" And I said, "Physics and physiology. This has been approved." And she said, "By whom?" And I said, "By the executive committee of the graduate schools." And she said, "I run the Dean's office and I don't care anything about the executive committee." And I said, "Why can't I?" And she thought hard for a moment and said, as her face lit up, "Because there is only one line for a head of a department on which to sign."

I finally persuaded her that one might sign above the line and the other below, but ever since then I have found that trying to bridge merely two fields of science has been a difficult matter.

UNIDENTIFIED DISCUSSANT: As one who is more or less forced into being a generalist by circumstances, starting out as a scientist, I would like to suggest that part of the problem is the very structure of our own profession. It is not possible to be a generalist and still remain in good repute with your colleagues. You become suspect the instant you depart your field of specialization.

BRONK: It is interesting being suspect, occasionally.

UNIDENTIFIED DISCUSSANT: And as a result of this, the heads of almost all research institutions in both Government and academia have a strong tendency to be specialists. The only exception is industry. I would like to suggest that one of the most important things this meeting might do to advance the cause of the future environment would be to come out with some form of resolution in favor of more generalism in science.

BRONK: Will you allow me to present some consideration about something that perhaps has been discussed too much but that I would like to emphasize? I would like to formulate a question. The problems of how to improve the challenge that is necessary for man to survive in a changing world must be considered here only in this part of the world, that is, the minority, the affluent society. Or we must consider this problem on a planetary scale—because, as you know, the problem is quite different in the two worlds.

The first problem is how to do something to change man. The man of today has more or less the same type of brain—the same weight and the same number of cells—as Neanderthal man. What has changed in man is his cultural approach. So if we have to do something to survive, we must try to promote a counterrevolution in man, to adapt man to a world that is quite different from the world before the atomic era.

Can we do this? What kind of motivation will convince people that they need to do something to avoid the difficulties and complications of tomorrow? And that is not easy, especially in what we call backward areas. You must not forget that in traditional society every act of man is a ritual, and you cannot change a part of the ritual if you do not change all the ritual. It is not easy to inoculate a trait of culture in a system of ideas on a certain culture.

If you will allow me a few seconds to tell you what I observed in a country that tries to change things for the better: Many years ago in the Soviet Union I said to my colleagues, "You are nutritionists in this country; do you have some kind of food deficiency or not?" They looked at each other and told me, "No, all kinds of food deficiency have disappeared with the Revolution." But I said, "You have no kind of vitamin C, you have no greens, you have snow everywhere. Don't you have some scurvy?" They said to me, "No, we have not."

I said, "Why, what do you do not to have it without vitamin C?" They said, "We have vitamin C." "In which way?" One of them said to me. "We give vitamin C to children in tablets, in pills, and everybody has enough vitamin C." I said, "That is very good," but after the meeting some of them

took me aside and said, "Would you like to see signs of scurvy some 20 kilometers from here." And I said "Why?" "Because in cities we can give vitamin C tablets, and everyone takes it, but out of the cities the old woman says 'I will not give this pill to my children because this pill is just so that they can become Communists'."

So they continue to have scurvy. And yet this story shows that even in a regime of force it is not easy to inoculate an isolated strain. If I tell this story, it is because everybody here, or most of you, tell about the tremendous problem of pollution because humanity is increasing. You must control that. So we must convince the people that they must have birth control. It is not easy to convince. First, I don't know if you are all quite sure that it is necessary to do this, and that it is the best way.

Let us see what happens in Latin America. Suppose I am a Brazilian. My country has nine people to each square kilometer. In the Amazon area, which is larger than Europe, we have one-quarter of a person per square kilometer. Could you recommend to these people not to reproduce because they have too many? It is difficult. So it seems to me that we need better motivation, motivation really capable of proving that you are in the right way and not in the wrong. If you continue to be in the wrong, to take decisions that are very good for the well-developed countries, but not for the rest of the world, if it is not integrated in a positive sense in the economy of the world, it is integrated in the negative sense because the demographic explosion is in the third world, it is in the backward areas. So we must do something, but with good motivation, with reasonable arguments, not because it is in the interest of our affluent society, in countries that have not yet the minimum of people to develop themselves. That contradiction must be clarified and clarification must be interdisciplinary, around a board of science, the crossline of science, the point at which many sciences contact each other. It seems to me that you must discuss openly, telling what everybody thinks, to counterpose points of view, because nobody is a prophet of truth; truth is everywhere. We must confront points of view, see our contradictions—and nothing is more contradictory than our own civilization.

EMILY MUDD: I wonder if in Latin America there was no overpopulation in the slums of Rio de Janeiro and other cities.

UNIDENTIFIED DISCUSSANT: If you will permit me, I want to come back to this problem of overspecialization—which is, of course, of basic concern. I speak not as a scientist, not even as a university person, but someone who worked in international organizations and who is concerned with communication. Our biggest problem is the fact that both intellectually and administratively we have separate specialties, separate concepts, separate interests, separate empires, and I quite agree that the real issue is not an intellectual one but an administrative one. If you do not make a career, the funds are not obtained until you fit into a clear-cut framework that forces you to specialize. This, to us in international agencies, as to everybody else, is a primary handicap when it comes to a subject like ecology that cannot be solved by any one discipline because it involves communication, which involves the social sciences, which involves the natural sciences and common action.

And this is why I would like to make a plea to the academic community and equally to the organizational community, that instead of focusing on the discipline, we have to be able to focus on the problem. And we must express such focus on the problems in organizational and administrative terms; otherwise we will never be able to get to it.

The issue is a very complicated one in each individual institution, but the academic community itself preserves the disparity of effort throughout the academic community, and whatever we can do here to reorient the focus I think will be welcome.

DE CASTRO: May I say one word? I would like to answer the comment about the slums of Rio and the other slums in Latin America. We do not have slums in Latin America because Latin America is overpopulated; we have slums because Latin America is exploited in a colonial way: its produce is very badly paid for in relation to industrial goods. So the people who work in agriculture leave these areas to live in slums in cities. It is a problem of economics, not of overpopulation.

HEDÉN: Of course, Dr. de Castro knows much more than we do in Europe about the situation in Latin America, and certainly what he said about birth control in Brazil, for instance, is obviously true. It is not because population density is too high that birth control, or control of the development of growth of the population should be considered in Brazil. This argument, which is good in India and Asia, is not at all applicable in Africa or in Latin America. In these countries, if you have a stable population twice as numerous as it is now, the standard of living could be higher. But the difficulty is that if the yearly growth of population is too high, (three percent in Latin America is the average) it makes it extremely difficult to raise the standard of living of the population. One very important point: it is impossible to give instruction and education to children because there are no schoolhouses. It would be much easier to raise the standard of living in Brazil if the population were growing by one percent a year instead of growing by three percent a year, and I think this is completely independent of the actual density of populations growing too fast.

UNIDENTIFIED DISCUSSANTS: I would like to comment upon this question about generalists, with which I am very much involved. I have dropped out of the university consciously because I could not accept the one view that was presented of a fragmentized world, because I cannot comprehend reality in this way. And I have been trying to fill the word "interdisciplinary" with some real content. Many people talk about this, but there is very little effort to put real content into it and really try to identify the problems involved. And I would like to pinpoint a few problems that may be of interest.

What is called the interdisciplinary approach is not at all interdisciplinary, it is at best multidisciplinary. That means you have, in one corner, a sociologist and in another corner a psychologist and in other corners other scientists, and they come forward and discuss their papers and together, in someway, modify the papers. Interdisciplinary means more thorough sessions and coming to a final conclusion together. The real thing that is needed is what you call transdisciplinary, in which, from the very beginning, you come together and make the basic definitions of what should be included in the study or research together, and write, as much as possible, in joint session.

Then I would say that among the problems I think you mentioned, a generalist is not accepted because you are looked down upon, you lose status: the status system is based on the specialist approach, and it is also a question of individual scientists' daring to do this. It comes down to some psychological problems I have experienced myself: you suddenly start to lose—you're not sure you are doing something sensible, and you have a feeling of what should be included and not be included. And it is much easier when you have a clearly defined field. I would like to know if there is any research, from a

psychological point of view, on how you can overcome this insecurity or the need for the kind of security of a specialist approach. I think that if one could solve that problem, a lot more scientists would dare to challenge their administration more strongly.

MEAD: We have done a great deal of work looking at the people who come from interdisciplinary or multidisciplinary conflicts. I have had about 30 years of this, studying the people who went to pieces and who had temper tantrums and said that we ought to abolish this group and settle down to seven instead of 20. And I think we can make one generalization: not every scientist is good at this kind of transdisciplinary work, and some of them are severely hurt by being asked to do this. They should be left right in the field of their little laboratory and never taken out. And if they are taken out and get interested in interdisciplinary work and get put in charge of important institutes, that is one thing. There is nothing worse than a narrow scientist converted to multidisciplinary work.

The other thing is, we can say reasonably carefully who the people are who can do it. They are people who do not have to command every step in a process but who can cross over at the top, take something that another group of people say, trust them, and who, on the whole are logical thinkers. Someone who is able to tell people, in the center of their laboratories studying sleep, that that is one of the things they should study. And let the people who can bear crossing over the top not control the processes at all. People who can bear two or three others talking to each other with equations they do not control—they are the group of people who make good transdisciplinary people. And I think we ought to start building our teams and looking at our students and saying which students are going to do well in one kind of field and which in the other.

BRONK: I am going to call on Hudson Hoagland next, but first, I remember very well when I was a research student and I asked him whether it was dangerous for a person with broad interests to go into scientific research. He said, "I cannot think of any *good* scientist who has broad interests." And I thought, alas!—but then he went on to say, "But I cannot think of any *first-rate* scientist who does not."

HOAGLAND: This group reminds me of a passage in Chapter 12 of the Book of Daniel, where it says "Many shall run to and fro and many shall be increased." I hope this is the prediction of this occasion.

I was asked to prepare a paper on what I thought were important developments in biology, medicines that would have marked impact on man and men's relations with each other over the years. In puzzling about this, it seemed to me that there were three major fields that are appropriate for this purpose. One is obviously molecular biology, with the implications of so much that has happened with the development of our knowledge of biochemistry in relation to the genetic process. A second question that seemed to me of great importance was the impact of new discoveries in brain and physiology of the brain on behavior and the possibility of controlling behavior through increased knowledge of the brain, which has implications of considerable magnitude. And third, the question of fertility control—which, after all, is a biological problem. It is a question of how we may control fertility and so control what I regard as a major social disease, the social disease of overpopulation in various areas of the world, which, unless it is brought under control, can be a disaster for mankind.

These three topics all have implications for our concept of values and our views about ethics, and it is in that perspective that I have been thinking about these matters in relation to these questions. I agree with Dr. Sager that the most exciting development in science in my lifetime has been the discovery of the mechanism of gene action through DNA, RNA, protein synthesis, and all that this implies for our views about the number of processes in biomedical science. I feel that what I have written in my paper about this is not as thorough or as good as what Dr. Hirschhorn discussed earlier. He covered considerably more aspects of this, because I was trying to put too much in too short a space, and I recommend that you ignore that part of my paper and read what he wrote.

But I am very much interested in the role of our advancing knowledge of molecular biology in connection with cancer and its control, and the nature of differentiation by way of nucleic acid processes, and the role of viruses and their DNA—perhaps in realizing orderly growth processes that result in cancer—and what can be done about this and how it may affect our future.

I think it is almost certain that aging, something that we have already heard about today, human aging, aging of animals as it is determined by molecular processes, DNA in particular, is determined by the genes. And the life span differences of individuals, I think, is determined by the genes. Thus, we all know people who become senile at 60 and others who go into their 90s with very little sign of senility. These remarkable differences certainly are not learned processes, nor are they nutritional processes; they certainly reflect genetic activity. I think we must approach this question of longevity through these new discoveries in molecular biology.

Fertility control is a topic that has been of great interest to me over many years. The pill was discovered by my colleagues at the Worcester Foundation some 18 years ago, by the late Dr. Pincus, Dr. Chang, and a group of collaborators, so that we have been immersed in aspects of fertility control and are still very active in our laboratory in working on problems of conception at a biochemical level.

Certainly something must be done about the very serious problem of world population growth, which averages two percent, which doubles the world population in 35 years. An infant born today would, at the age of 70, know a world not of 3.5 billion but a world of 14 billion people; his grandson living to the age of 70 would know a world of 60 billion people. Nobody thinks that the world could accommodate 60 billion people in anything like a meaningful condition. So this is not very remote, and something certainly must be done about it.

We have been concerned with the population growth rate in the underdeveloped countries primarily; the poverty of these countries and the number of unproductive mouths to feed has been the most conspicuous aspect of the population explosion. We recognize that starvation is very likely now, and massive starvation in the very near future. The green revolution probably will not be able to reduce starvation and perhaps can postpone it for only a decade or two. But as long as the population is burgeoning as it is, this is not going to be the solution.

We know that in the developed countries, whose growth rate is lower—the United States, the Soviet Union, and Japan have about a one percent annual birth rate—this growth rate will double the population in 70 years. But our population growth has a much more damaging impact on our environment,

a much more serious ecological impact because of the pollution that we spew around and because of the tremendous consumption of irreplaceable raw materials as the standard of living goes up. We represent, in the United States, only six percent of the world's population, and we are using 40 percent of the irreplaceable fuels and metals. In addition, it has been calculated that the birth of one American child, in the development and amount of material he consumes, takes up anywhere from 25 to 50 times what will be consumed by an Indian child. So the impact of our society on utilization of materials and our introduction of very serious pollution is a matter of great concern.

Now, the contraceptive agents are being studied and worked with, but I do not believe that better contraceptives are going to be the answer to this at all. Better contraceptives are on the way. The pill has been a good one, and it has been effective, particularly because it introduced new concepts to many people about control of population. When we started work on the pill, we were insulted and got letters telling us that we were murderers, but now all of that has changed. We are in a Catholic country, and there has been no indication of that at all in recent years. In fact, it is quite the contrary. But despite the fact that a number of women are using the pill, its major impact has been in changing the attitude of the public toward some of these problems that are so serious. I also think that population control is really a psychosocial problem, and how to change this is a great question. We have been seeing a remarkable liberalization of our abortion laws. I would not have believed it possible that the New York State Legislature, in my lifetime, would have voted as it did in liberalizing abortion. And this is true in many other states, a very encouraging sign. The extension of vasectomy as a population-controlling aid is gaining considerably. And these are very significant changes.

However, voluntary family planning may not be the answer at all because in India and in other underdeveloped countries—in most of the larger countries where population problems are acute—women say, yes, we would like to have family planning, and they say this is great. They take pills or IUDs, and instead of having eight children, five or six of whom used to die, they now decide they want five children all of whom live, so that the net effect is to increase the population rather than decrease it.

Perhaps we will have to face the fact that people will have to be more or less forced to control the size of the population. This is a most unhappy thought, but in order to have freedom we have to obey laws, and if we are going to load our so-called spaceship earth down with an incredible number of people, it will curtail freedom all down the line.

What are the ethics of population control at this social level? There is a great deal of talk about tax reductions for those who refrain from reproduction for a period of time. There is a question of licensing the having of children. All this is shocking to most people. I remember 15 or 20 years ago, the Indian ambassador told us that what India needed most was a safe, inexpensive contraceptive that could be put in food and drinking water, willy-nilly. Otherwise, he felt little hope for India's future. The idea of putting a contraceptive in the drinking water is horrifying to people, particularly when they think of what complications fluoridation has had. This bizarre idea might not be so far away, because a substance has been developed by Upjohn that can predictably reduce the offspring of mice and rabbits when put in their drinking water. It is tasteless and relatively untoxic to rodents, and for humans it is not too toxic. It is horrifying to think that this substance may become available in the near future and may be accepted in the countries where population is becoming a problem.

There are a number of other approaches, of course. The need for a form of social security of people in the underdeveloped countries is very great. In India, the number of sons one has can assure social security, because sons are necessary to carry on the farm and say prayers for the parents when they die and see that they get taken care of in their old age. With some form of social security, the need for many sons becomes increasingly unimportant. With the education of women, their emancipation so that they can get jobs and do something outside the home is of great importance. A study in Egypt shows that the university women have just about as few children as our university women here; as one goes down the educational scale there is a progressive increase in the average number of children for each group. The freedom of women to be educated and to have jobs is an important aspect of this.

Another suggestion has been made of reversible sterilization of women after they have had a child. Presumably this could be done in the future, perhaps by a contraception agent that is being developed at Rockefeller University by Sheldon Segal. It is a tube that can be fitted into a hypodermic needle. Inside the tube is a very small amount of a steroid substance that will seep out continuously from the tube into the circulation after it has been injected into the skin. The evidence is that this will produce a failure of the woman to conceive. It does not block ovulation the way the pill does. It would appear to affect very much more subtle chemical processes involving the action of the sperm with the egg, and this is confirmed. And if it is as harmless as it seems, it might be used as a way of guaranteeing that a woman would not have a child for a period of time, because one injection of this material is good for months and perhaps even years.

Finally, in dealing with the other subject that I am concerned about, behavior, we do know that neurosurgery in various areas in the brain, the use of specific agents and injections into the circulation that goes to the brain, electrical stimulation of certain parts of the brain with cranial implant electrodes can markedly change the personality of the patient. Animals can be converted from highly aggressive to tame. There are very frightening, very wide-ranging ethical implications that can be discussed at great length.

CALHOUN: I would like to comment on what Dr. Bjorksten was saying about priority to focus on senescence rather than on the many particular aspects that lead to it, and that, with a ten percent increase in our efficiency in dealing with the senescence problem, we could double the life span. This again is a selection of priority. In the definition of ethics, we can broadly interpret a widespread consensus to focus on something that would double the life span. The selection of direction is the generic issue in priorities.

If, for example, we double the life span, we will have compounded the question of population, which we have not yet solved in any way. Even if the population question is a very simple one, we focus on numbers; we have to say numbers of what? And it is a much more complex issue in deciding these very generic problems. I think we must turn to a poetic examination of the issues, as Dr. Porter mentioned in physics, the little black spots in the universe where no information is being disseminated. We are at the critical stage in evolution, within a century of the end of the new phase of evolution introduced with man some 40,000 years ago. The question is whether evolu-

tion will continue, and this is the salient issue that overrides all other issues. We have to make some decision about this now, and by *now* I mean within no more than 15 years. We have to make major decisions that will alter the total course of evolution. My favorite example comes from Africa, at Lake Manora, where the fishermen pull out 40-pound fishes, but those fish disappear from time to time: the lake dries up and those fish go down in the mud. You can drive trucks over the top, and these animals have very effectively made an adaptation to rigorous changes in the environment by which they avoid change and avoid stress. We are in just about this point in evolution at which we can cut off all the threatening aspects of our environment, and I see this as a major issue. And it defines health, the generic concept of health, and for that I would like to go back to the early Roman pharmacologists, who gave written symbolic incantations to Jupiter to bless their compounds. Normally, we have carried over this tradition under the Rx, the sign for prescription. And if you will continue a word that is now commonly used on college campuses and elsewhere in the world, but now spells revolution, with this symbolic incantation to Jupiter in front of it, it reads design of evolution, or prescription for evolution, and I think this is the major definition of health; that we are healthy only to the extent that we are involved in commitment to the design of evolution.

I have worked in population problems, and you have to keep stepping back from the immediate issue to these longer-range issues, try to see what we are really involved in. I believe that this is the major generic direction: that we, living now, are the ones who will decide whether the main process of life will continue. And that is the evolutionary process itself.

UNIDENTIFIED DISCUSSANT: Dr. Hoagland took up the question that I thought a little frightening, namely that you should spread contraceptives in the water, whose nature must affect not only man but also the animals. I think this is extremely dangerous. I would rather believe, as Prof. Ruth Sager said, that one should try to establish certain rights, such as the right of every woman to know how she should proceed in order not to have more babies. The experience from Europe is that that is enough. We have already too few babies in many countries in Western Europe and certainly in Eastern Europe. In Hungary, they do not even reproduce themselves, the population is falling. So I think it is more than necessary that we give this right to everybody.

But this clearly has political implications because we have to force a change in the family structure, for instance, in the Moslem countries, so that the woman gets education. We have to challenge the Catholic church in this respect. One has to ask if it should not be the right of the woman in the Catholic worlds to decide for herself on this point, because I understand this is not what is happening now.

DE CASTRO: I agree. I am not against what is called a population policy. That is absolutely necessary. I am against what I could call generalized population control, because nobody has the right to say that we are overpopulated; we have used only 15 percent of the soil that can be used to enrich our people. We know that most of the country is not overcrowded, so the problem is too complicated to be oversimplified. And urging this solution for underdeveloped countries is wrong and dangerous.

First, it is dangerous because, if you do that and forget to do the other things, it is a negative solution; you do not bring real development, you stop development just to mediate a short-term program. And we must get at the heart of the real solution.

Another reason is that I am not quite sure any program of birth control compelled from outside could be a success. It must be a failure, so it is a failure in two senses; if it does not go well, it is a failure, and if it goes well, in 20 years it is a failure because the population of this country becomes an old population without young people to reproduce. So the real problem of what I call the population metabolism is developed by education, because the real development is the human development, the development of man.

If you educate people, you have the relevant formation of people by real knowledge of their own problems, they know that they can control in reasonable measure the size of their families. That is the right solution of the problem.

To finish, I agree completely with Monsieur Perrin that the population explosion is a factor that can block the development of the underdeveloped countries, such as India. But that underdevelopment began before the explosion of population. Overcrowded and exploited populations are a product of underdevelopment and not a factor of underdevelopment.

THE WORLD WE WILL LIVE IN *

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Every sentient human being is aware of the dangers as well as of the opportunities that now confront man. He is also aware of the pressure of forces within himself and the pressure of forces around him. Caught between his inner world and the outer world, he feels dissonant more often than consonant. He feels stress, longing, and frustration. His soul feels weary, and he yearns to find, and to express, the meaning of his life. Some among the most "successful," and many in the midst of "great riches," appear to hope for something else.

Science and technology are indicted by some as the cause of this malaise, and some even recommend antiscience and antitechnology remedies. However, in the absence of a true understanding of the current syndrome, it is unwise to ascribe the causative role to something that may not be the cause or to prescribe as a remedy the elimination of something that could even help in the development of remedies. Although science and technology are unlikely as a cause they are, nevertheless, a force with which man must cope.

The views just expressed are similar to those contained in the preface of a book called Living Tomorrow Today! which says:

> As we are brought closer in touch with the world in which we live, it is apparent that *the physical and spiritual health of a single individual, and mankind as a whole,* should be the final yardstick in measuring both progress and problems. As tomorrow comes closer to becoming today, we are reminded that, to a degree far greater than in any time in history, *the future will depend on whether our ethics and values can keep pace with our scientific and technical knowledge.*

And in the prologue of this book, in reference to scientific and technical growth, Isaac Asimov says the following:

> But all these advances, coming upon us faster and faster from every direction must be correctly handled, and that isn't easy. Living tomorrow today involves confronting *the enormous problems which must be worked out in order that our limitless opportunities may be properly used to the benefit of all people.* All of society is altering widely under the impact of advancing science, and *all mankind is being carried furiously forward in a mad race toward a not completely visible goal. We must stay in control so that tomorrow's life will be worth living and that today's hope will beget greater hope.*

* A version under the title The Two Epochs was originally presented before the American Institute of Aeronautics and Astronautics in October, 1969 and the present version was delivered before the National Association of Manufacturers in December, 1969.

If the progress and the problems of man are to be measured in terms of effects on the single individual and on mankind as a whole, we need to examine the nature of the relationship between the individual and mankind, and if the future of man depends on ethics and values, let us also examine ethics and values in relation to the individual and to mankind. Because ethics, values, individuals, and mankind are all bound together in the effects expressed in the physical and spiritual health of man and the quality of human life, as is the survival of mankind, not only do we need to look into the past but we must also try, through our imaginations, to see as far as we can into the future.

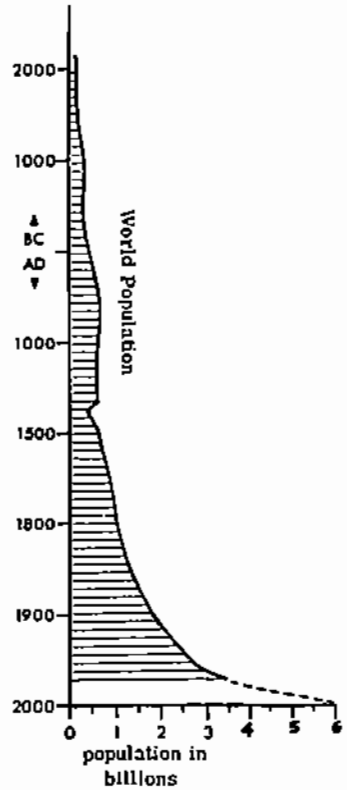


FIGURE 1. World population estimates, 2000 B.C. to A.D. 2000.

We must not overlook the long evolutionary history before the beginning of man's own history. Man's population history is shown in Figures 1 and 2. Here we see the long gradual increase in world population until recent time, when the rise became almost exponential. The only interruption in this progression was a dip due to the effects of the bubonic plague, in the 14th century when the world population was reduced by about one-fourth. It soon returned to the level the resources then available could support and man's biological and ecological condition would permit. As time advanced, as territories opened, as resources were developed, and with the improvement in hygienic conditions and

food supply and hence in man's physical health, there was a prolongation of life expectancy, and the annual excess of births over deaths resulted in the enormous increase in numbers now present on the face of the earth.

Projections based on current trends reveal, in FIGURES 1 and 2, an unfinished picture, through the year 2000. A world undergoing such rapid change will affect both the individual and mankind—with profound implications not only for ethics and values and the quality of life but for the survival of man.

Shifting our attention to another species, we see what happens to a fly

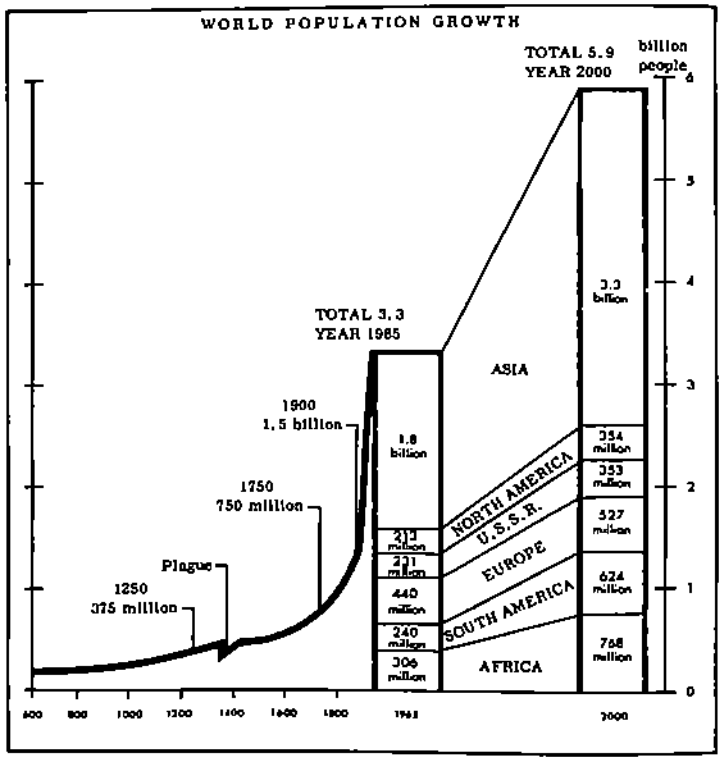


FIGURE 2. Population by world areas, A.D. 600–2000. By permission of John McHale and George Braziller, Inc., from The Future of the Future, © 1969.

population in a closed system—a system in which space and resources are finite. In FIGURE 3, the curve of growth of a fruit-fly population is shown. This curve, the first part of which resembles the world population curve, reveals a deflection at the mid-point, along the steep slope, because of a change from acceleration to deceleration and then a plateau. This deflection is emphasized in FIGURE 4 by interruption of the curve at the point of change from progressive increase to progressive decrease; in FIGURE 5 the difference is still further emphasized by displacement with the creation of curve A and curve B.

It is of particular interest, in the present context, to note that curves such as

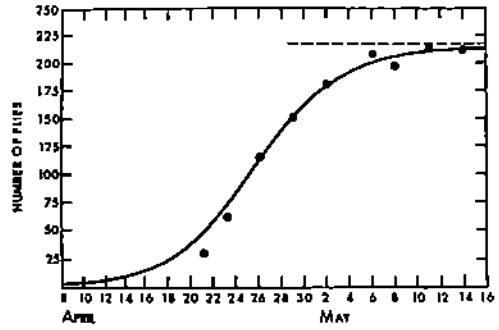


FIGURE 3. Growth of fruit-fly population.

these resemble curves that describe other self-controlled or self-regulated phenomena in living systems that are referred to as homeostasis, a term coined by physiologists. Homeostasis refers to the maintenance of "optimal levels" through control and regulatory mechanisms, and is sometimes metaphorically regarded as evidencing the "wisdom" of the body—or, more broadly, the "wisdom" of nature—the seeming "purpose" of which is "survival" of the individual and the species. Such innately programmed phenomena, in which deceleration of production occurs when "enough" is produced, are seen, for example, in the formation of a specific hormone, or an antibody, or blood cells after blood loss, or tissue cells in repair after injury.

"Optimal levels" are the cumulative and integrated result of the natural selection of forms that best fit prevailing circumstances. The biological "wisdom" so revealed expresses itself through a complex constellation of physiological systems that sense and signal "not yet enough," or "enough," and then respond appropriately. Such systems for sensing and responding vary in degree of sensitivity and in degree of responsiveness—some react to small stimuli, others to large; some have a short lag, others a long one; some have short-term effects, others long; some are reversible, others irreversible; but all are part of an order that we recognize functionally as health and that evolved by trial and error.

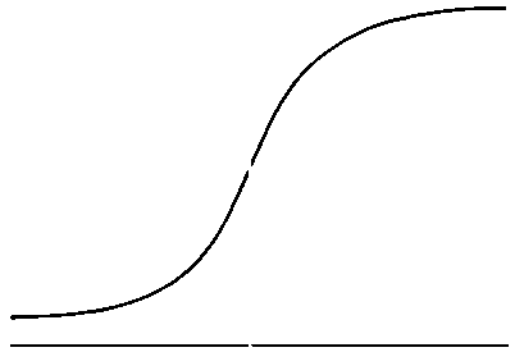


FIGURE 4. Schema of population growth and decrease in acceleration.

As I look at these curves, and feel myself in them, my imagination becomes playful and begins to ascribe human attributes to the fly population. I imagine that if flies possessed the human attributes of "foresight" and "insight," the *outlook* of each succeeding generation would differ, and furthermore, the *outlook* in what I think of as Epoch B, would be qualitatively different from that in Epoch A.

I even imagine, in each generation of this fly population, a sense of "responsibility" for the *future* and a need for a mechanism for discharging this "responsibility." If control is at least partly "voluntary" rather than entirely "autonomic' or "physiologic,' (as is, in fact, true of the fruit-fly population) the flies would have to "evaluate" and "decide" before "taking action." This would mean that for guiding effective action the "system of values" in Epoch B would have to be different from that of Epoch A. These are the thoughts that occur to me as I imagine myself a part of these curves.

When I then look at the curves of population growth of man, I sense the existence within us of an innate "sense of order" similar to the "sense of

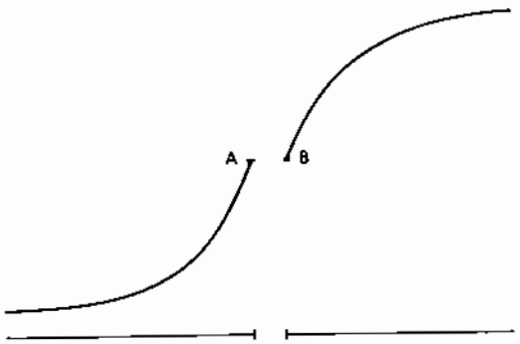


FIGURE 5. Illustration of break between population growth and decrease in acceleration.

order" that exists in such physiologically regulated biological systems, as systems of molecules, or a population of flies in a closed system; and that through this innate "sense of order" we become aware when we begin to have "enough." I also sense that we are now becoming aware of a need for a fundamental change in our value system—a change appropriate to the difference between Epoch A and Epoch B.

In historical terms, I conceive Epoch B as starting with the generation now maturing. From all parts of the world there is widespread evidence suggesting that Epoch B is already well underway and that a *new ethic* for the *new epoch* has already begun to evolve.

In the new epoch, we need to look at ourselves from a biological viewpoint, rather than from such other viewpoints as have been dominant in Epoch A, to be able to shape a *new value system* for our time.

The idea that the biological viewpoint might provide a point of departure for developing a workable and livable ethic for the new epoch requires further elaboration. The biological way of thought is here used in an attempt to

develop an understanding of what appears to be an epochal change in man's view of himself at a point in time when his survival is threatened by products of his own creation and when the need for self-discipline to avert disaster is required more than ever before.

It would seem, from the present state of man and the world, that an uncompromising ethic based upon something as real as "survival" is needed.

Evolution is a game of life and death in which there can be no loser and no winner for evolution itself to survive. Thus, life and death must coexist for the survival of life in evolution. In a similar way, life's problems and solutions are inextricably related, because solutions almost always lead to the creation of other problems, as we see, for example, in problems created by the solutions produced through science and technology. In the same way, species and the individual are inseparable. It is not possible to have a species without individuals or individuals without a species. It follows from this that any ethic for man requires that whatever is regarded as of value for the individual must also be of value for the species, and, conversely, what is judged to be of value for the species must also be of value for the individual. Such an ethic would be based upon the idea that *man and species are one*—and, ultimately, that *nation and mankind are one.*

Species that have survived possess well-developed, gene-controlled, self-regulating mechanisms that respect the environment and are "species-oriented" rather than "individual-oriented." As far as I know, there is no other species that is "individual-oriented" to the extent seen in man. In an "individual-oriented" society is to be maintained, then an ethic and a system of values must be developed that will make this of value for the species as well as for the individual. Such a culture would require an equal sense of responsibility for others and for oneself. Greed and self-service would be of negative value in such a culture and would have to be regulated and controlled.

Thus, an ethic and a value system are supplementary to biologically operated mechanisms of regulation and control and can also be inhibitors of the natural mechanisms for regulation and control. Changes in ethics and values, and changes in moral and religious codes, should be looked on as part of the evolution of effective human control and regulatory systems toward the goal of an ethic in which *man and species are one*—when *nation and mankind can then be one.*

For the foregoing ethic to become operable so that we may then be able to use our limitless opportunities for the benefit of all, it will be necessary to understand self-regulation and self-control, both within individuals and within groups. Man seems to know this intuitively and seems to desire this. Moreover, he seems to be moving in this direction. At times, in utopian euphoria, he goes too far one way—and then to opposite extremes, as he continues to acquire the experience necessary to support the faith and confidence that, given the opportunity, man can more often be generous, kind, and loving.

This is the sense that moves young people to reject the prevailing ethic and to look at earlier metaphysical philosophies for guidance in their search for meaning in their lives. The need for a philosophy could be satisfied by a realistic idealism, such as can be developed from the biological point of view. This will require an enormous amount of imagination and thought. Simple in the abstract, its accomplishment is perhaps the most difficult and crucial challenge with which man will ever be faced. What is involved is the ultimate question of man's survival and the nature of the quality of his life in the future.

A self-consciousness of evolution could be of great value. Will man supplement his less experienced wisdom with the more experienced wisdom of nature? Will the ethic he espouses and the value system he develops follow patterns of proved value in nature?

Life is an error-making and an error-correcting process, and nature in marking man's papers will grade him for wisdom according to the judgments he makes as measured both by survival and then by the quality of life of those who survive. Although the lives of individuals have been prolonged and made more secure, and man has been able to go to the Moon, the survival of the species here on Earth is threatened by uncontrolled population growth as well as by an atomic holocaust—which one individual could touch off. All these are the accomplishments of science and technology.

The dinosaur, in its day, was jeopardized by environmental change and by predators, both of which led to its extermination. Man is now the cause of major environmental and ecologic change and makes predators out of his fellow men through an ethic and a value system that permits and encourages us to so conduct our lives. Man, therefore, is pitted against his species.

It is necessary for man to see himself as he really is and examine the paradoxes of his life if he is not to destroy his species by a progressive elimination of options. Will man see himself as he is, in relation to his future, and act appropriately on behalf of his own survival?

Those in positions of leadership, who are able to influence the course of events, will soon reveal whether they possess within themselves and whether mankind possesses within itself the capacity for long-term survival—with meaning and satisfaction in life—or merely for a chronic, agonizing, short-term survival. It will not be long before we know. The dangers are great. Will we see that the opportunities are greater—and that the choice is ours to make?

Will we help the evolution of an ethic and a value system appropriate for our time, and will we contribute toward the development of a trajectory for man that will lead to the destination he seems to want to reach? The price for this is high in terms of his personal ego or image and his national ego or image, but the reward is great in terms of his true and natural self. Will man have the wisdom, the courage, and the strength to take the course to long-term survival, or will he—in ignorance, fear, or weakness—accept the world we now live in as the best we can create?

WHY FERTILITY CONTROL?

Hudson Hoagland

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Continuation of the present rate of population growth is a threat to all mankind. The application of techniques of modern medicine and public health since World War II to underdeveloped countries has markedly reduced death rates, leaving birth rates, always large, either unchanged or increased as the result of improvements in health and longevity. In many of these developing countries, increases of 20 years in life expectancy have occurred in the course of one or two decades—increases that took roughly a century to bring about in the United States and in western European countries. Population growth today depends only on the difference between birth rates and death rates, because there are no more vacant lands for colonization by people from crowded countries.

World population today stands at some 3.6 billion and will double in 35 years at its current growth rate of two percent, so that by the turn of the century we will have some 7 billion people on earth, and in an additional 35 years, at our present growth rate, there will be 14 billion of us. Thus, a child born today and living on into his 70s would know a world of this number of people, and his grandson would live to see 60 billion people. Even the most optimistic can hardly think that our planet can support such a burden of humanity.

Most concern with the population explosion has been expressed for the underdeveloped countries, which are being held back by the production of excessive numbers of children who are consumers, but not producers, who grow up hungry, and often with less education and job opportunities than were available to their parents. Capital for industrialization, for agricultural machinery, and for fertilizer plants is very hard to get, because produce for exports to obtain capital must be consumed locally. Competent economists and demographers predict mass starvation on a scale hitherto undreamed of in countries of Asia, Africa, and the Near East in from ten to 20 years. The so-called green revolution, the production of improved rice and wheat crops, is no answer. At best it can fend off the day of reckoning by only a decade or two.

But, quite aside from food, there are other very serious considerations, because direct correlations have been made between occurrence of wars and revolutions, poverty, and rates of population growth, so that the likelihood of drastic population reductions by a third World War, with nuclear, chemical, and biological weapons, is increasing as human misery expands with numbers of hungry, ignorant, and frustrated people.

Studies of animal societies have demonstrated conclusively the pathology of crowded living—of "pathological togetherness," as John Calhoun has called it. Animal societies are organized in terms of dominance hierarchies, and their structure makes possible effective social living with a high biological survival value. Under crowded conditions, even with ample food, the social systems of gregarious animals collapse because of the stress of crowding, which operates

via the hypothalamic-pituitary-adrenocortical axis. This has been demonstrated for many species, both in the natural state, in zoos, and under experimental laboratory conditions. The social collapse results in much fighting, highly abnormal behavior, loss of sex drives, failure to make nests, and cannibalism of the young. As a consequence, the population density falls to levels in which social organization can be re-established effectively, then the population builds up again and the cycle repeats. There is evidence that crowding of people in concentration camps also has resulted in pathological behavior, and many of the problems of the slums and ghettos may very well be a byproduct of the stresses of social overcrowding, although this has not been adequately investigated.

We often overlook the tragic consequences of our increases in population in the developed countries. A one percent growth rate, which is an average for some major industrialized countries, e.g. the United States, the U.S.S.R., and Japan, will double populations in 70 years. The United States, with our present growth rate, will have some 300 million people by the turn of the century, and it is the rich countries that are doing most to destroy our biosphere by pollution. So serious is this question of pollution of land, air, and water and the consumption of irreplaceable metals, fuels, and natural resources by the industrially advanced countries that competent scientists believe the world cannot indefinitely support even the 3.6 billion people we have on earth today, let alone the horrendous numbers anticipated for the relatively near future.

We are assaulted by noise and poisoned by carbon monoxide and other noxious fumes from a hundred million motor vehicles. Thousands of tons of pollutants, many of them highly toxic, are being pumped into the air from industry, jet planes, and automobiles, producing widespread smog, which is increasingly visible over relatively deserted areas far from industrial centers. Already a thousand million acres of arable land have been lost to erosion and salt through human activity, and two-thirds of our forest lands have been lost. A hundred and fifty species of birds and mammals have vanished altogether in the past two centuries, primarily as the result of human activities.

In the United States, annual wastes and pollutants amount to 142 million tons of smoke and noxious fumes, 7 million junked automobiles, 200 million tons of paper, 48 billion cans, 20 billion bottles and jars, three billion tons of waste rock and mill tailings, and 50 trillion gallons of hot water. These figures have been furnished by the staff of the Secretary General of the United Nations.

Reports from West Germany note that millions of dead fish were found floating down the Rhine, poisoned by the accidental spilling of some 300 pounds of an insecticide into the river. The danger of contamination was so serious that Amsterdam, Rotterdam, and the Hague switched to emergency supplies of drinking water. Prior to this accident the Rhine was referred to as an 800-mile-long sewer. Pesticides in 1960 wiped out vast numbers of fish in the lower Mississippi, and industrial wastes long ago exterminated shad in the Delaware and in the Connecticut rivers, shellfish in the Merrimack, and all edible fish in the Hudson nearly to Albany. Various hawks, including ospreys and eagles, at the end of food chains that concentrate DDT, are facing extinction. The United Nations report links the dangerous deterioration in world resources to the simultaneous world growth in population. The problem is indeed a global one. The fat of seals on the Antarctic icecap has been found contaminated with DDT and other pollutants—and, of course, our burgeoning

upsurge in numbers of people makes the extensive use of pesticides a necessity in order to feed them. Our skill in producing washing detergents and such plastic materials as wrappers has produced a vast amount of waste material that cannot be attacked by bacteria, and thus rendered innocuous, or destroyed, with the result that our advances in technology are costing our environment dearly.

Carbon dioxide and toxic gases from industry and motor cars is increasing, and CO_2 in the atmosphere has a "greenhouse" effect. It slows radiation of heat from the earth, particularly at night, while having relatively little effect in blocking entering heat from the sun during the daytime. This tends to raise the temperature on earth, and it has been calculated that, in something of the order of a thousand years, we may expect a sufficient rise in the mean temperature to melt the Antarctic icecap, which would raise the ocean levels by some 300 feet and swamp out all cities within miles of coastlines. Happily, the temperature's rise is not as rapid as it would be were it solely from the "greenhouse" effect of CO_2, because solid pollutants producing our damaging smog, including discharges from jet planes, have the effect of retarding the entrance of heat from the sun, tending to balance out the "greenhouse" effect of carbon dioxide.

In a recent book, Dr. Charles F. Park, of Stanford University, holds that the world population already is well beyond the number that can be supported by our planet. He bases this on the fact that we are consuming our mineral resources at a rate that cannnot be continued for long and he discounts the argument that ample mineral resources can be obtained from the sea because of the excessive cost. Our technological society is consuming metals at an appalling rate, which will rapidly increase if and when the developing countries become industrialized. In 1967, the United States had a per capita consumption of about one ton of iron. He argues that, if global consumption reaches that level by the year 2000, and the population has doubled, the world's annual demand for iron will be 12 times that amount. In similar considerations, assuming the doubling of the population and industrialization of global areas not now developed, he shows that there will be a 16-fold demand for lead and an 11-fold demand for copper over today. These figures are based on the assumption that there will be no increase in per capita consumption by our highly technological society between now and the turn of the century, and such stagnation is highly improbable.

We are, of course, rapidly exhausting our supply of fossil fuel, with the expectation that nuclear reactors will take the place of the oil and coal burners to supply energy. With the shift to nuclear fuels, there will be increasing problems of disposal of nuclear wastes in air, land, and water and this will markedly accelerate dangerous contamination of our biosphere, with threats of increasing malignancy and genetic damage.

It is the industrialized rich countries that do most damage to their environments. Indeed, most serious overpopulation has been defined as occurring in that nation whose people, because of their numbers and activities, most rapidly deplete the ability of land to support human life. The United States is generally regarded to hold first place, in view of our affluence and vast industrial complex, with the pollution it pours forth and its consumption of raw materials. Wayne Davis has compared us to India. He suggests that we speak of our numbers in "Indian equivalents," which he defines as the average number of Indian citizens required to have the same detrimental effect on the land's

ability to support human life as would the average American. This value is difficult to determine, but he takes an extremely conservative working figure of 25 and concludes, with this Indian equivalent of 25, that the population of the United States is now equivalent to *at least 4 billion* in its environmental damaging effect compared to India, and the rate of our growth is even more alarming.

There are only two solutions to the social disease of overpopulation. One is to increase death rates and the other is to decrease birth rates. No one that I know advocates the former solution, although an all-out nuclear war would solve the population problem. Fertility control on a rational basis is the only other answer.

The "pill" was developed by the late Gregory Pincus and M. C. Chang at the Worcester Foundation for Experimental Biology and their principal collaborators, John Rock and Celso Garcia. It has proved to be a safe and effective oral contraceptive, despite scare headlines about side effects. Present oral contraceptives are a beginning, and work with other compounds and other methods of fertility control are of great importance in coping with population problems. This is so even while we recognize that ignorance, prejudice, and a variety of social and psychological factors are the primary limiting conditions of population control. In time, governments may find it necessary to act to protect their people against their prolific reproduction. This is indeed an abhorrent idea to most people, but voluntary family planning is not effective in most countries and the present growth rate can be utterly destructive of civilizations if uncontrolled.

How can governments act to control population? Various suggestions have been made.

1. Senator Packwood of Oregon is proposing a bill to limit Federal income tax exemptions for increasing numbers of children. He would have $1,000 exemption for the first child, $750 for the second, and $500 for the third, but none for subsequent children. On the other hand, Paul Ehrlich would eliminate all tax deductions for all children and would add luxury taxes on diapers, baby bottles, and baby food.

2. Various cash awards could be given for couples who refrain from having children for definite periods.

3. Bachelors in many European countries have been taxed rather heavily to encourage marriage and children. This process could be reversed, and single people could be given tax advantages.

4. Late marriages could be insisted upon by governments.

5. Liberalization of abortion laws and encouragement of male sterilization.

6. Temporary sterilization of all single girls by means of an implanted time-capsule contraceptive, and of all women after each delivery, with reversibility allowed only on government approval, based on government decision as to population size.

7. Compulsory sterilization of men with three or more living children.

8. Various studies have shown that education and jobs for women reduce the numbers of children. Therefore, more education and more jobs for women.

9. A Federal bonus could be given for child spacing, and tax and welfare benefits, with penalties for those who do not.

10. It has been pointed out that the development of government social security systems in developing countries can have a marked reducing effect on population growth. In India, for example, the only social security parents now have is the production of at least one son, who will carry on the farm and provide for their old age, including the necessary religious rituals so that they can join their ancestors. In the past, with death rates very high, it was necessary to have many children to assure that one son would survive to care for the parents. A Government social security system could take the place of the security furnished by surviving sons, as it has done in industrialized countries.

11. Some 15 years ago, the late Indian Ambassador, Mr. Chagla, said that Indian's most pressing need was for a safe, cheap, effective oral contraceptive that could be put in food or drinking water to reduce fertility. Recently, Melvin Ketchel has pointed out the probability that one or more such substances may become available in the near future, and he discussed the ethical and social problems that would be associated with its use. He pointed out that such a substance would, of course, not be used to sterilize a population completely but, depending on concentrations employed, could reduce fertility statistically to predetermined desired levels, including, of course, the level of zero growth.

Considering the furor over fluoridation of water supplies, one can imagine the public uproar that even the discussion of such a procedure would induce. Compulsory government control of fertility in any form is abhorrent to most people, but it may well become necessary for survival itself if voluntary methods fail as they seem to be failing in many countries, including those whose governments accept and promote voluntary family planning. If we do not control our populations, I believe that a nuclear war will do it for us. Man is the only animal that can deliberately control his own evolution. Let's hope he chooses rational procedures rather than a nuclear holocaust.

The American people are deeply enamored of the virtue of growth for its own sake—growth in population, growth in business enterprises, growth in armaments, growth in gross national product. We even measure the virtue of our automobiles by their size—the bigger, the better. It is my hope to see the time when quality of life will be separated from quantity in our value systems and that any politician who boasts that he has ten children would be regarded as too socially irresponsible to be elected to important public office.

If and when this day comes, we shall have control of our population problems as well as most of the problems of pollution.

CONTROL OF POPULATION: NUMBERS

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Inclusion of this topic on the agenda of the present assembly reflects a widespread concern about this poorly defined topic. No solution of the human population problem will be reached unless we can gain more appreciation of the item man to be counted or of the meaning of control. Furthermore, neither control nor counting may proceed rationally without placing the human present into an evolutionary perspective embracing both past and future. My intent here will be to consider sequentially (1) evolution, (2) counting, and (3) control. In treating the subject in this manner, it will be apparent that I am forced into a holistic view of the issue. Much of the position taken here is developed in detail elsewhere.[1, 2, 3] I am purposely not trying to summarize the opinions of others relating to population control. Rather, my purpose is to develop a philosophy about the problem that will help us navigate a resolution of the population crisis.

Evolutionary Perspective

Man as a biological species reached his present form about 57,000 years ago. At that time, the world population stood at about four-and-one-half million. This population was formed by nearly 150,000 hunter-gatherer bands averaging 12 adults and 18 children. The average band inhabited a territory nearly 15 miles in diameter. Despite intervening changes in body size, territorial extent of bands, or range of the species, it is highly unlikely that the biomass of man increased more than tenfold during the previous million or so years. During this long period of relative constancy of numbers and biomass, technological innovations of both genetic and cultural origin permitted those groups that were more efficient in extracting resources to supplant less efficient ones.

However, beginning about 40,000 years ago, a drastic transition in population growth occurred. The world population doubled repeatedly. We are now witnessing the tenth doubling, and those now born may see an eleventh doubling—to nine billion—a 2,000-fold increase in only 40 millenia. Each successive doubling required only half the time of the prior doubling. From the first doubling, requiring 20,000 years, the 11th could take only 20 years. Initiation of this unique trend marked the transition from biological-man-only to man-become-human. Unless we appreciate the import of this pattern of population growth, unique in the animal kingdom, solution of the present population crisis will remain illusory.

Up to the beginning of this human era of evolution, man, like so many of his progenitor species, lived in relatively closed social groups, which, on the average, rarely exceeded 12 adults. Through millions of years of evolution, genetically based alterations of physiology and behavior arose that optimized satisfaction from life within such small groups. Conforming to these alterations required maintaining a way of living that would ensure continuance of this small-group existence from generation to generation. Meeting this need for intimate social living became the barrier that prevented biological man from becoming human. Man, like his lesser brethren, could optimize gratification from social living only if contacts with associates continued at the rate that normally occurred within a small group of about a dozen adults.

The capacities for reproduction, with survival into adulthood, regularly caused groups to exceed this optimum number. As the size of any group approached twice the optimum, the rate of increase in frustration from unsatisfactory interpersonal contacts became maximum. At this time, the group would split and one portion would emigrate. Its only chance of survival lay in its capacity to replace a less efficient neighboring group. By this means, technological efficiency increased and total world population was preserved relatively unchanged.

The essential limiting factor to an increase in total population was the genetically built-in need of each individual to experience meaningful contacts with neighbors at a rate consistent with that in a small semiclosed group. Movement within the bounds of the band's territory ensured this rate of contact. Because all available inhabitable space had long since been filled with territories of hunter-gatherer bands, no increase in total population was possible. Increase remained impossible until an essential discovery simulated invasion of uninhabited physical space. It permitted social contact at greater physical density to proceed at the same rate as if the members of each larger group were distributed over a greater physical space.

Elaboration of social roles provided the key to this simulation of physical space. Whenever a group invented or adopted new social roles, its numbers within the former domain could increase accordingly without the necessity for emigration. At the first social breakthrough, some 40,000 years ago, a simple sexual differentiation of roles was sufficient to permit the group to increase from 12 to 24 adults. Within each of these two role-defined subgroups, most members gained most of the satisfactions of social living from within their own subgroup relations. By this tactic, the rate of social contacts was preserved in harmony with that demanded by the genetic constitution of every individual. Each doubling of group size and each doubling of population demanded a related increase in the number of social roles.

Such increase in social roles required comparable increases in the concepts that made social relations more effective. As the population increased in a given physical area, added concepts permitted more efficient mining of resources. Both of these categories of concepts derive from the total information pool available at any time. This total pool of information represents an equivalence to physical space and may thus be termed "conceptual space."

At the time the world population stood at about four-and-one-half million, it was primarily limited by available physical space and by the unmodified natural resources contained therein. Beyond this level of world population, every further increase in the numbers of man required discovery of additional conceptual space. At present, 99.9% of the space we live in is conceptual. (This is not to gainsay the importance of the 0.1% of the space we inhabit that is physical. Our present environmental crisis reveals how mismanagement of this now very small component of our "spatial" requirement threatens our survival.)

Codification of the information forming this conceptual space into usable

concepts has proceeded at a rate that makes this total pool of concepts proportional to the square root of the magnitude of conceptual space. We may equate this pool of concepts with human potentiality. Because increases in conceptual space are proportional to the increase in total world population, it follows that with each quadrupling of population, human potentiality doubles; the item that is the average man so doubles.

These trends of increase in population, conceptual space, and human potentiality were possible during the past 40,000 years only to the extent that two related but independent processes exhibited parallel development. The first of these includes such prostheses for information storage, transfer, and transformation as written documents and computers. The second linked larger and larger numbers of individuals into effective sociopolitical networks. Both of these contribute to the rapidity and effectiveness with which we "move" through conceptual space. By sustaining these two processes, man has been creating successively larger and functionally more complex social brains. Brain as a generic concept merely relates to the union of elements that permit the storage, transfer, and transformation of information. Progressive development of social brain largely replaced the evolution of biological brain that terminated as the current, or *sapient*, era of human evolution and population increase began, 40,000 years ago.

This eruptive increase in man's numbers will need to continue only as long as it contributes to the evolution of social brain. Increase in numbers should continue until all adult members of the world population are effectively united into a single sociopolitical network. As we look back over the character of prior unions during the past 40,000 years, a general pattern may be seen. On the average, each doubling of world population has been accompanied by a set of seven of the then extant larger sociopolitical unions coalescing into a new and larger social unity. Thus, each time world population doubled, the geographic extent of the social brain increased sevenfold. Continuation of this general trend has led to an increase in sociopolitical enclaves, or social brains, from a diameter of about 15 miles to the extent represented by larger nations today. This evolutionary course makes a world population of four-and-one-half billion consistent with achievement of a state of union in which seven sociopolitical entities encompass all mankind. Conforming to this evolutionary picture means that by about 1985 there will have arisen seven such unions. In a similar fashion, final world union should be reached during the first quarter of the next century. Attainment of this union will demarcate the level of population beyond which further increase will no longer contribute to evolution of social brain or to an increase in human potentiality.

Upper Optimum Population

If the past trend of population increase continued unabated to this time of world union, the total world population would stand at nine billion, which might be defined as the upper optimum. "Unabated" includes the criterion of a ratio of three children per two adults in the standing population. If this ratio dropped to 2.2 children per two adults, consistent with approaching a stable population, the optimum would drop to about seven-and-one-half billion. However, there are reasons for suspecting that continuing the evolutionary process of enlarging social brain and increasing human potentiality beyond the

time of world union will require a continuing slow decline in world population. To initiate such a decline as average life expectancy increases requires a further reduction of the number of children to 1.5 or less per two adults. If this degree of fertility decline is achieved by the time of world union, the upper optimum world population would stand at 6.3 billion or slightly below. Thus, taking an evolutionary perspective leads to the conclusion that an upper optimum world population will contain approximately 3.6 billion adults and enough children to produce either a stable population or a slowly declining one.

Ideomass and the Item Man Being Counted

In either case, the nature of the item being counted has been treated only by implication. We are concerned with the individual as measured by his potentiality for adding to the total information pool (conceptual space) and from its creating new concepts and acquiring and utilizing existing ones. As already pointed out, the potentiality of the individual doubles each time the population quadruples. This means that with each fourfold increase in population, the total capacity of mankind as an assembled species increases eightfold. Multiplying the average potentiality of the individual by the total number of individuals provides a measure, *ideomass*, of the capacity of man as a species. Therefore, when we speak of controlling population, we are concerned with numbers only to the extent that their product, with the average potentiality of the individual, affects ideomass. To place individual potentiality, world population, and ideomass into perspective, we may look at the degree of increase each should have attained by the time of world union early in the next century, in contrast to their magnitudes at the time of transition, 40,000 years ago, from biological-man to man-become-human. Individual potentiality will have increased 45-fold; adult world population 2,000-fold, and ideomass, 90,000-fold. Our present crisis is only partially one of numbers; the main crisis pertains to ideomass in which numbers and individual potentiality are the basic factors.

Over the evolutionary-historical past, ideomass has continued to increase. This increase has been made possible by linking more and more people together into a social network to form more effective brain. But at the time of attaining the upper optimum world population, the linking of people with people, as neurons in a social brain, can no longer contribute to increase in individual potentiality, which can arise only as brain in its generic sense enlarges. This enlargement of brain previously arose from an interaction (product) between expanding networks of people and an expanding repertoire of information storing and processing prostheses. With only this latter factor functioning to increase brain, the rate of increase in human potentiality will be so gradual that it will fail to provide the stimulus for further invention of those informational prostheses required to further expand human potentiality. For all practical purposes, as long as world population is unchanged in numbers, ideomass will remain constant. This means that human potentiality will remain constant. The pattern of life will become ever more rigid and traditional. Complete cultural traditionalism will then terminate the continuing experiment that has been man. His cultural template governing behavior will make him as strictly instinctive as are the simpler creatures controlled by genetic templates that elicit predictable behavior in constant environments.

To remain human, man requires an ever-changing environment and a continual expansion of his own potentiality. If ideomass remains essentially constant, these two requirements may be met by developing a declining population and further expansion of informational prostheses. Each successive halving of world population will probably take twice as long as the prior halving, so that 165,000 years from now, population will stand at about the level reached during the Golden Age of Greece. With each halving of population, individual potentiality can double.

Basic Variables in Population Control

Against this perspective of past and future, we may now evaluate the present period of acute transition between two eras of human evolution. Our concern with the number of men on earth derives primarily from the way that changes in number affect individual potentiality and ideomass. In order to avoid overemphasis on numbers alone, we must examine how fluctuations in other variables have the same consequence as alteration of numbers of individuals.

Social Roles: Any inadequacy in the availability of social roles in relation to an existing physical density has consequences comparable to increasing the size of the population. In the absence of such roles, the frequency of unsatisfactory social contacts will increase. Furthermore, many avenues for fulfilling a potentiality consistent with the population size will not exist. Social disorganization that produces ineffective utilization of existing roles will also have an impact comparable to increasing population.

Linkage: Where individuals, institutions, or various levels of government are too ineffectively linked to facilitate the storage, transfer, and transformation of information necessary for realizing a fulfillment of potentiality, the population will, in effect, be too large.

Prostheses: Inadequate development or utilization of informational prostheses has the same implication as ineffective linkage.

Education and Creativity: The realization of potentiality for development requires acquisition of concepts about role playing, functioning in communication networks, mining resources, and utilizing informational prostheses. To the extent that education fails to provide these, overpopulation exists. Furthermore, becoming more human follows from a continuing expansion of potentiality, which can arise only from the invention of concepts that replace or are added to prior ones. In this sense, the creatively deviant person forms our most precious commodity. In his absence, each person added to the population contributes much more to overcrowding.

Each of the above four variables must be considered in any formulation of population dynamics. They determine the magnitude or capacity of the item, man, being counted. A Kalahari Bushman might be equated with a Norbert Wiener in so far as caloric intake is concerned, but were all members of the world population of two thousand years ago at the level of conceptual development of Bushmen, that world would have been far more overpopulated than it is today, even though at present most roles are not filled with persons of Wiener's potentiality. Simply counting bodies, without considering how each contributes to ideomass, has little relevance.

Fertility: Finally, we come to the variable that, currently, is nearly always the sole consideration in seeking a solution to the impending population crisis. Technological and behavioral means for sufficient fertility reduction to produce either a stable or a declining population exist. Though better means will probably be discovered, the question of means is the least important problem in either the control of the numbers or quality of a population.

Mortality: Termination of physiological functioning—biological death—removes one from inclusion in a population census. If we extend the definition of mortality to include cessation of any kind of functioning, then any individual so characterized becomes subject to removal from the roles of a population census, though he may still survive biologically. Loss of social functioning, in the sense of no longer being able to work toward a fulfillment of potentiality consistent with an existing population level, amounts to death. Fostering such social death is far more inhumane than inflicting physical death. These two kinds of death must be included in our assessment of population dynamics.

An Experimental Study of Social Death

Studies are under way in my laboratory that provide insight into the relationship of population dynamics to social death. The subjects are an inbred strain of house mice. Though they are far simpler creatures than man, they nevertheless give us a picture of man's possible future destitution.

Artificial environments have been designed that consist of modules or cells, each of which represents a socially optimum situation for nine adults (three males and six females). In each cell, accessibility to food, water, and shelter could permit survival of 25 times that number. That is to say, physical resources essentially do not represent limiting variables. Five universes are currently being studied, consisting of one, two, four, eight, and 16 cells, respectively. Each has followed a similar history. Population growth continues until density reaches about 160 mice per cell—eighteen times the optimum. At this maximum density, reproduction essentially ceases.

From the time of initiation of the population in each universe with four males and four females, to the time of maximum density, the number of socially active males per cell rarely exceeds three. "Socially active" for this simple species implies roles in the contention for, acquisition of, or maintenance of a territory. Some young males who enter the social milieu may succeed in replacing a territorial male. Other young males contend for a time before total rejection from the social flux of status striving. All such replaced dominants or rejected contestors became recruits in a socially pathological category of withdrawn males. No longer having access to the sheltered living spaces, these males aggregated in compact pools in exposed public space. The withdrawn males restricted their motor activity to the minimum required to obtain food and water. They exhibit a marked lowering of the threshold of tolerance to disturbance; very minor dislocations of their usual sedentary relations precipitate violent episodes of aggression that culminate in severe mutual wounding without any attempt to escape.

As the population increased in numbers, comparable pathological changes took place among females. Increasingly many females began to exhibit male-type aggressiveness in public space outside the sheltered living spaces. As these shifts in behavior became more pronounced, more and more females lost

the capacity to build and maintain nests adequate for sheltering their young. We know very little about the specific ways in which altered maternal behavior or the intrusion of subadults alters the experience of young mice. However, the consequence of this altered experience is drastic and apparent. Both males and females fail to mature socially. Behaviorally, they continue into adult life as juveniles, without the capacity for either mating or aggression; their normal adult roles never emerge. Females move into adulthood with rare, if any, pregnancies. Males return to the nesting boxes where they associate with their nonreproducing sisters, with males like themselves, or with the few remaining reproducing females. We term these males the "Beautiful Ones" because they are physically perfect specimens, free of the wounds characteristic of behaviorally more adequate males, who moved out into the social scene.

At the maximum attained density, about 18 times the optimum, all of the more recently born males are Beautiful Ones; no new contenders emerge. The socially active males senesce and die, as do the large aggregates of withdrawn males living in public space. A few of the older, aggressive, male-like females exhibit territorial defense, but the bulk of surviving adults have lost their potentiality for engaging in the normal reproductive and aggressive roles. After viewing these studies at this stage, Mr. Mayer Spivack of Harvard applied the term "overliving" to these populations. If the current conditions of failure to reproduce persist, the populations will be "overliving" in the sense that surviving individuals no longer contribute to the survival of the population.

Even if some few individuals are able to recoup their normal behavioral roles after many of their associates die, the essential point of the above account remains valid. Where there is no physical escape from a closed environment, and where no capacity for elaboration of roles prevails, social death may mark up to 95%—151 out of 160, approximately—of the population. Had such populations existed in more normal ecological settings, this 95% would have fallen into émigré category, moving to suboptimal habitats, where most would soon have died from predator action or other mortality factors. This raises the question of warfare. Man has often been called the only species that engages in warfare. From a comparative and evolutionary perspective, the term *warfare* must be broadened to include all deaths within a species resulting directly or indirectly from actions by members of their own species. In this light, we may examine where man is now. We recently reached a time when there were 1.2 billion adults, with a life expectancy of approximately 50 years after weaning. During their lifetime, perhaps no more than one million persons per year have died from all kinds of warfare, from simple homicide to nuclear attacks. For adults only, we may thus take 50 million deaths out of a population of 1.2 billion, roughly 4%, as the currently attained warfare mortality. During biological and cultural evolution, warfare mortality has been reduced from 95% to 4%. If world union materializes within the next century, warfare mortality should become even more negligible. As a factor in controlling population, warfare has become less and less important from an evolutionary point of view.

Therefore, we will be faced more and more with the problem of social mortality. Studies on both animals and man suggest that the stochastics of a dynamic social setting will usually produce an 8% to 16% social mortality that correspondingly reduces ideomass. Further decrements in ideomass accompany the social morbidity of realized potentiality falling short of that which should characterize the attained population size of biological bodies. The planet Earth is becoming progressively a closed system within which there is no physical escape. If adequate measures are not taken to provide habitable

conceptual space, the prevalence of social death and morbidity will increase. And if we focus excessively on simple control of the numbers of the biological entity that is man, our effort to preserve the human experiment will be endangered.

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Natality: Here, too, we are circumscribed by a too-narrow concept of natality by restricting it solely to biological birth. Though we may wish to reduce biological natality enough to produce, first a zero population growth, then a population decrease, natality as a broad generic concept may continually increase for the foreseeable future. As a broader generic concept, natality includes both the birth of new ideas, and their spread and acceptance by a larger segment of the population.

Control

This broadened concept of natality encompasses the essence of control, with control implying the design and management of future evolution, of which the number of men, accompanied by an increasing individual potentiality, is a major component. Creation of new ideas is a major essential form of natality to be continually enhanced. Relatively few individuals are involved in this category of reproduction. However, every individual is faced with the need to evaluate emerging ideas, accepting those judged valid, and participating in their dissemination. This process of value change is a kind of midwifery by which ideas are born into an entire population.

"Control of population: numbers" may be realized only through the functioning of an inclusive population policy encompassing a set of interrelated subsidiary policies and their implementation. If we take as our goal a survival of man that enhances the continuation of the human experiment, priorities of policy implementation become apparent:

1. Evolutionary designing.
2. Value change with conflict resolution to foster acceptance and spread of ideas.
3. Education and opportunity for fulfillment of potentiality.
4. Enhancement of the linkage of individuals and institutions into communication networks.
5. Family planning.
6. Promotion of creativity.
7. Development of technological prostheses to extend the capacity for storage, transfer, and transformation of information.

This is my personal assessment of the priorities within a comprehensive population policy.

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CONTROL OF POPULATION GROWTH AND FAMILY PLANNING

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"To put it simply, the greatest single obstacle to the economic and social advancement of the majority of peoples in the underdeveloped world is rampant population growth," said Robert McNamara, the President of the World Bank Group, in an address at the University of Notre Dame on May 1, 1969.[3] He went on to emphasize the urgent need for family planning, implying that if the developing countries really mean to make progress, it is essential for them to give Government support to family-planning programs and thus have control over the growth of their populations.

Mr. McNamara is a statesman of great caliber and integrity. His sincerity and dedication are beyond question. I have quoted his speech because it typifies the thinking prevalent among the circles that lay the pattern of economic and social development for the underdeveloped nations.

There has been considerable misunderstanding about the aim and role of family planning. Some have tended to confuse it with population control; others have tried deliberately to equate the two.

This bracketing of family planning with control of population growth, although aimed at helping the cause of family planning, is, unfortunately, having the opposite effect. It is assumed by many so-called experts that it is necessary to play up fantastic "population projections" and to paint gruesome pictures of the human race menaced by overcrowding in order to convince couples to practice family planning. This assumption is wrong. Well-informed and responsible people in the developing countries are not in the least convinced that the alleged excess of population is the sole or primary cause of starvation and poverty in these areas. The hypothesis that, if family planning is practiced, the growth of the world's population will be effectively controlled, is fallacious, although there is a deceptive substratum of plausibility in the hypothesis. The argument that control of population growth is essential for economic development can be substantiated neither by facts and figures nor by the history of the developed nations.

Family Planning

Definition

Family planning means voluntary control over the timing of each pregnancy. It is not synonymous with fertility control, the object of which is the prevention of births. Each family-planning clinic has a twofold function: first, to guide and assist couples to space their pregnancies according to their own planning; second, to use all available knowledge, when requested, to assist

those who have failed to have children or to help couples who already have children to increase their family to the number of children they desire.

The objective of family-planning movements is to make available to all couples the means and knowledge whereby, on a voluntary basis, they can have the number of children they want.

Motivation

Various voluntary organizations and some governments have been motivated to institute family-planning programs because they realize that unplanned, unwanted, and unlimited numbers of pregnancies have serious ill-effects on the mental, social, and physical health of the mother and child in particular and on the family in general. In addition, appreciation of the suffering endured by childless couples has caused treatment of infertility to become an integral part of family planning. It should be noted that almost 20 percent of couples either fail to conceive at all or fail to have the number of children they want. In Kenya alone, there are about 300,000 women whose inability to conceive has jeopardized their physical, social, and mental well-being. An equal number of males have similarly been affected by their inability to have children.

At the individual level, motivation is primarily the inherent wish in man to provide his children with a better standard of living than he himself had. This desire cannot assert itself in societies where people are still existing below subsistence level. However, wherever man has risen above that level, his focus of interest has shifted from the provision of food for his family to ensuring better opportunities for his children and the desire for smaller families begins to emerge.

Factors That Can Promote Family Planning

Family planning is a felt need of the human race.[1, 2] It should be appreciated that:

1. there is universal desire for control of childbearing and there exists today a considerable reservoir of demand for guidance and assistance in family planning;
2. not enough is being done to meet the existing demand, primarily because of the wrong emphasis by the developed nations; actually, more money is being spent on propaganda for family planning than for assistance to those who want to practice it;
3. there is considerable pressure on governments in the developing countries to initiate and support family-planning programs; however, in view of the fact that their medical services are handicapped by lack of funds and qualified personnel, this has limited value;
4. as has been stated by Dr. Philip M. Hauser in his paper, "Non-Family Planning Methods of Population Control," "Despite the proliferation and notable progress in family planning programs in recent years, there is as yet no evidence that a zero-rate of growth can be achieved by the developing nations or by the world as a whole by the century's end. Moreover, it is doubtful that family planning programs, as conducted at present, can even significantly reduce population growth rates during, at least, the remainder of this century.

These conclusions are based on the following considerations: (A) The world has yet to witness a family planning program which initiated a decline in fertility in a 'traditional society' characterized by mass illiteracy and poverty; and (B) The examples of 'successful' family planning programs to date, e.g. Taiwan, Hong Kong, Singapore, South Korea, are in areas in which fertility declines had already begun before the advent of national family planning policies and programs, and which have rising levels of education and income per capita so as to preclude the extension of their experiences to populations still steeped in illiteracy and poverty."

5. family-planning programs cannot have any significant effect on the population of the world today unless the voluntary approach is abandoned in favor of sanctions or incentives. This is because, in the case of backward areas of the world, in the words of President Nixon, "the development has not yet reached the stage where it would bring with it diminished family size." And in the case of such advanced nations as the U.S.A., the U.S.S.R., the Netherlands, dependence on the assumption of the so-called rationality of the behavior of relatively advanced human beings is proving wrong.

The declaration of the United Nations Organizations that 28 countries have, by mid-1969, initiated official family-planning programs, should lull no one into complacency. All these countries happen to be poor in personnel as well as funds. The pathetically low standard of their family-planning services is notorious. Improvements in the clinical standard of services offered at these clinics are urgently needed.

It should be realized that large areas in the developing countries are provided with no clinics at all. Clinics in areas where they do exist are typically poorly equipped. They are understaffed, and the staff is, in most cases, not sufficiently qualified. Their concern and keenness seldom extend beyond the distribution of the "pill" or pushing in the "coil." They make no effort to provide even a minimal degree of medical examination, which is absolutely necessary before any useful and acceptable assistance can be given to any woman. People outside the medical profession do not seem to appreciate that the women who usually visit these clinics are undernourished and chronically ill because of their numerous pregnancies and many other factors. Most of them are likely to be suffering from one or another minor ailment. Anemia, low-grade pelvic infection, and malnutrition are very common among patients who are likely to visit family-planning clinics in the developing countries. The examination and assistance given is often hurried, scanty, and tactless.

It cannot be too strongly emphasized that it is only the woman who is the highly motivated acceptor who will come to the clinic at all. If she leaves the clinic upset or dissatisfied with the treatment, her unfavorable comments will travel far and wide very rapidly. Those who receive satisfactory treatment are much less likely to talk about it. At present, the situation is such that not many women leave the clinics with a feeling of satisfaction. The spreading of information by word of mouth is far more effective in the developing areas than television, radio, or newspapers because of the mass illiteracy and poverty of the population. Therefore, funds available should be used not for propaganda for family planning but for the improvement of existing clinics and for the establishment of new ones. It is indeed immoral to pressure more people to go to the clinics when those who are prepared to go must endure unfortunate experiences. *Thus, the improvement of present facilities and provision of additional ones is the most important single factor to be considered if family-planning programs in the developing countries are to be successful.*

More research into more effective and more acceptable methods of family planning is also essential. The amount of money spent on cancer research appears out of all proportion when one realizes that many fewer people die each year from cancer than die or remain sick because of unplanned pregnancies. If a fraction of the money now spent on cancer research were devoted to family-planning research, many more lives would be saved and better methods of family planning and of management of infertility would be made possible. If adequate research is done, we may be able to predict that, in time, every woman will be able to know in advance the exact date of her ovulation by simply using a piece of test paper, which would eliminate the necessity of using pills or I.U.D.s. Restraint for a couple of days or the use of some suitable precautions for that time will eliminate all risk of an unplanned pregnancy.

As custodians of the health of the human race, I must admit that we medical practitioners have not given due cognizance to unplanned pregnancies as a health hazard and a great danger to human well-being. The medical profession has just begun to recognize the importance of this source of ill-health, disease, disability, and death. We have only recently started teaching medical students and paramedical staff about unplanned pregnancies as we have been teaching them about other diseases and dangers to human well-being. Unfortunately, this practice has not yet become universal. I believe unplanned pregnancy should be described in textbooks as a public health hazard and a social disease, and chapters should be included that consider incidence, natural history, prevention, management, complications, and sequelae, just as we do with other diseases. It is important that we dissociate ourselves from the sentimentality surrounding unwanted pregnancy. It is our duty to impart knowledge about how unplanned pregnancy affects the health of people. We have shown no reluctance in training students to perform such operations as removal of a diseased uterus, knowing full well that certain students will be prevented by religious scruples from performing that operation. We teach about prevention and cure of venereal disease while we appreciate its association with all that is unacceptable to most people on ethical, moral, and religious grounds. In the same way, we should have no hesitation about imparting knowledge about unplanned pregnancy. We should leave it to the individual to decide which aspect of this social disease he will not concern himself with.

Another vital factor in family planning that is almost always ignored is the high cost of drugs because of the exorbitant profits taken by the pharmaceutical companies. I shall give just one example of what I mean. A small plastic tube used for the insertion of the intrauterine contraceptive device—the coil—can be manufactured for a few cents. This device is being sold in Nairobi at the exorbitant price of $3.00 each. If the profits of the drug companies are not strictly controlled, it is quite obvious that conception control is going to remain far beyond the means of the average person in the developing areas.

Future Prospects

Social and economic changes brought about by independence, education, urbanization, and industrialization have directly influenced public opinion toward the approval of birth control regardless of the attitudes of state, society, law, family, or religion. Unplanned pregnancies affect the health of—and kill—more women between the ages of 16 and 45 than any disease known to mankind. For this reason and this reason alone, prevention of an unlimited

number of pregnancies through family planning will become an integral part of public health services in the developing countries within the foreseeable future. It is hoped that the important and responsible function of procreation will become a voluntary and planned act and that man will learn to dissociate it from the gratification of one of his natural appetites, namely, sex.

Population Growth Control

Definition

The necessary preliminary to any consideration of the relation between control of population growth and family planning is the distinction among the concepts of family planning, fertility control, and control of population growth.

Family-planning programs today are restricted to conception control. The objective of fertility control, on the other hand, is the prevention of births. Methods of preventing births include all the methods of conception control and, in addition, abortion—termination of pregnancy if conception has taken place. Control of population growth implies control of the rate of population growth. It encompasses not only fertility control but the control of the relationship between birth rate and death rate for the whole of the world. Population control on national bases will have to take into consideration the rates of immigration and emigration as well.

It is obvious that man can control only the *rate* of growth of the population, but cannot control the population as a whole, as it stands today. The term "population control" should be discarded in favor of "population growth control." It is not correct to assume that the population of the human race can be controlled as we have learned to control the population of the animal kingdom. When we say, for example, that pest control is effective, we mean that we can reduce the volume of the pest physically, and even eliminate it altogether. Population of man, on the other hand, cannot be reduced from what it is today with any acceptable method. All that can happen is that the rate of growth of population may be controlled.

Motivation

At an international level, population growth control is being advanced as a solution to the problems of destitution, deprivation, and underdevelopment of the poorer nations. Much effort is being expended to propagate the idea that if population growth in the developing nations is controlled, their problems will be solved, and that if their governments are made to officially initiate and support family planning programs, their population growth will be effectively controlled. A host of literature is being produced especially for circulation in the backward areas of the world to impress on the readers that their population is growing so much that very soon not only will there be nothing left for them to eat but there will be no room left even for people to stand. When one looks at the reasons given by the authors to justify the measures intended to reduce population, one simply cannnot find them convincing. What one finds is a series of fallacious arguments and endless repetition of the same slogans (the well-known propaganda technique) and of skillful manipulation of statistical data that, on the whole, penetrate the minds of the unwary.

One is often confronted in the press with articles that show the world as a sphere three inches across, overpopulated with people one and a half inches tall. The authors of such stereotyped articles and books do not seem to appreciate that to make a real case for population control, they must show, first, that the world is overpopulated, and, second, that it is incapable of feeding either the existing population or the increased population of the foreseeable future.

Now, to prove the first, it is impossible if you consider the following two simple facts:

(A) That, given a square meter per person, you can fit the existing three thousand million people on the Islands of Zanzibar, Pemba, and Marfia put together (3,000 mill square meters).

(B) That if you put the whole world population in the U.S.A., the resulting density would be that of Holland at this very moment, with the rest of the world quite empty.

As to the second point, that is, the capability of the world to feed its people, I refer to Colin Clark's article in the *New Scientist*, August 11, 1960, entitled "The Earth's Capacity to Provide Food." He estimates that with the present agricultural techniques, the earth could support 28,000 million people at the Dutch standard of living, which is not one of the lowest.

Of course, Colin Clark, the Director of Agricultural Economics Research Institute, Oxford University, and the *New Scientist*, a reputable scientific magazine, realize that to say that science or scientists support population control is a good slogan but it is not something that is going to convince any responsible and well-informed authority.

The same endless statements about the starving population of India are repeated, and writers advise India to reduce its breeding in order not to starve. The authors seem to ignore the fact that India, besides having a human population of four hundred million, has also a cattle-buffalo population of two hundred million (FAO report, 1965), and a definitely deleterious and costly population of between 2,400,000,000 and five thousand million rats. (The source of these figures is the Central Food Technological Research Institute, Mysore, 1965). The emphasis in all current propaganda is that instead of urging the four hundred million Indians to fight against the five thousand million rats, which eat a good half of their food, and to reduce the cattle birth rate, time and money has to be spent on convincing the masses of India to control their own birth rate.

It is believed by most of the influential and responsible circles in the developing countries that the birth-control campaign is organized by powerful pressure groups with headquarters in rich countries who want to prevent the poor from breeding because they fear that the poor might one day thrust them aside with their sheer bulk. Whether this belief is right or wrong, it is my opinion that the people in the developed nations should accept its existence.

The easiest and the least troublesome way, and the one that requires least sacrifice from the rich nations, is birth-control counseling. (See the prevailing slogan of U.S. economist Stephen Enke; $5.00 spent on birth control is worth $100.00 spent on aid (Belgrade Population Conference).

I want to emphasize once again that there are few knowledgable people in this world who will agree that the most important problem facing mankind is population, and that family planning is the answer to the hunger and starvation that exist on the earth today. Two-thirds of mankind is starving at the moment, although there is enough food to feed the present population.

At the national level, more and more nations have begun to take note of the relationship between economic development and population growth. Unfortunately, because of political considerations, few countries in the West have dared to establish comprehensive national policies on population. So far, there are not many reports that convincingly show that the population or the rate of growth of the population is the determinant or even the most important factor in the economic growth of a particular country. If one asks any citizen of a developing country whether he or she is having better food, better clothing, better education and, on the whole, a better standard of living than his or her parents had, the answer will be "yes." This puzzles them, because until yesterday they had been given literature predicting that they would have much less food and other amenities because they had been outgrowing their resources.

This is not to say that in most of the developing countries there is rampant population growth. It must be appreciated that even in the backward nations, a man today does not have the same number of children as his father had. And there is not a single nation in the world that is bent on increasing its population. The belief among the middle class in the West that the populations of the poorer nations are growing and will keep on growing without any restriction imposed on them by their changing pattern of social behavior is far from correct.

Factors That Can Promote Growth Control

It should be appreciated that:

1. People in the developing countries do not accept that the rate of population growth is the determinant or the chief factor in the economic development of a nation.
2. Population growth cannot be significantly controlled through family planning.
3. There is a great deal more to control of population growth by reducing the birth rate than merely the techniques of conception control that are dispensed at the family-planning clinics. Experience has shown that the birth rate of the traditional societies falls effectively only under the impact of urban-industrial development, education, improvement of health, and reduction of death rate. Propaganda for birth control or Government-sponsored family planning programs do not seem to have played much part in lowering the birth rate of the developed nations.

The unjustifiably exaggerated emphasis on family planning and its erroneous identification with control of population growth has annoyed and irritated the intelligentsia in the developing countries and has aroused opposition to family-planning programs from very influential political and religious groups.

If population control is really necessary, today's leaders should frankly campaign for it. Identifying family planning with population control smacks of an ostrichlike attitude. One wonders why there is not more emphasis on the other than family-planning methods of population growth control. In the U.S.A., family planning has been practiced quite widely for a long time. But it has failed to control effectively the growth of population there. By 1980, the population of the U.S. is going to increase by 50 million over the 1964 level. The Americans have admitted that they are not adequately prepared to feed, house, educate, or find jobs for these increasing numbers. In the words of William H. Draper, Jr., National Chairman of the Population Crisis Committee, "three hundred million Americans may be poorer in the year 2000 than we are today."

Similarly, the population in the U.S.S.R. is going to increase by 50 million during the same period, in spite of the fact that guidance and assistance in family planning are freely available. In the United Kingdom, the problem is in no way different or less threatening. It should be obvious to anyone that family planning and population growth control are two different entities.

Honest and sincere effort should be made to recommend non-family planning methods that can effectively control growth of population. It will be necessary for the developed nations to take the lead by declaring their own population targets and outlining governmental policies to achieve them.

It should be borne in mind that the increase in population in such Western countries as the U.S.A., England, Holland, and the U.S.S.R. is going to cause problems similar to those of the increase in the population of the underdeveloped nations. Whereas in the developing countries the present generation has more food, better education, and a better standard of living than their forefathers had, the restriction of emigration has been making it increasingly difficult to maintain the present high standard of living.

It is surprising on the part of the intellectuals in the developing nations that the same degree of concern and alarm is not being shown by the international circle. Not one developed country of Europe, nor, for that matter, the United States of America, has found it necessary to include its name on the list of governments that have declared to the United Nations their readiness to sponsor national family-planning programs.

Obviously, the time has come when objective and honest assessment must be made as to not only how the population growth in the world is to be controlled but also where and by how much.

Future Prospects

In the developing countries, the spread of education, improved medical services, the increasing urbanization, and the improvement generally of the standard of living have already lowered the death rate. This, in turn, is showing signs of lowering the birth rate also. It is the lowering of the death rate that is essential to the reduction of the birth rate. This fact has been established by the history of the developed nations. In the Europe of the 19th century, despite a steady decline in the death rate, there was no population explosion; the birth rate also went down. This happened before modern methods of birth control had been discovered and before the propaganda for population control had started. People managed to find ways to limit the size of their families. Europe changed from the old historic pattern of a high death rate and high birth rate to a new pattern of low death rate and low birth rate. It is wrong

to assume that the poorer nations constitute a static mass of flesh and that they will not undergo a similar process.

It is also clear that the death rate in the world will continue to fall. Men and women will be living, on the average, from 70 to 80 years. The world's birth rate will also drop, and the whole world will eventually take on the stable pattern of 19th century Europe, and the human race will live in equilibrium.

It is established that the factors that have caused the lowering of the birth rate in the advanced countries have been the same as have been responsible for the raising of the standard of living. Industrialization, urbanization, the spread of education, better health services, raising the age of marriage of women, are all noteworthy factors. No amount of propaganda for population growth control can take their place. The average age of marriage of women in India and Pakistan is 13.9 years. If it can be raised to, say, 20 years, six very fertile years can be eliminated from the reproductive life of every woman. That will mean reduction of from three to four children per couple.

There is already a strong tendency in the developing countries for women to marry late. It is expected that this trend will continue and will also become more widely accepted. Along with this, the rising status of women will to a considerable extent be an important factor in affecting population growth.

It is hoped that this paper will not be misconstrued to mean that there should be no consideration of the growth of the population of the world. Effort has been made to point out that wrong emphasis on family planning will not help us very much. Those nations that honestly want to control their population growth should be advised to consider non-family planning methods seriously.

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SUPERSPECIALIZATION: THE TREND AND ITS IMPACT ON AMERICAN MEDICINE

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The crisis in the delivery of health care to the American public today is in large measure due to the dramatic trend toward specialization and superspecialization of the past two decades and the obvious failure of our system to fill the void created. Almost everyone today is a specialist, many are superspecialists, and some are specialists of even greater magnitude.

In our pursuit of knowledge we may logically ask—is it synthesis or fragmentation that reaps the greatest reward? Or is one inadequate without the other?

The increasing frequency with which specialization and fragmentation occur creates implicit dangers that must be met directly. How frequently we hear of the benefits of the latest diagnostic or therapeutic triumph, which has improved the scientific level in the practice of medicine but has left the poor patient fragmented by the multiplicity of specialists or groping for appropriate guidance when the clinical problem is subtle and difficult.

How often do we find an individual really capable of accurately and effectively encompassing a broad perspective beyond his own special area, a person with extensive and varied knowledge who can see the forest for the trees, the strengths and weaknesses of each narrow subcategory within his own major discipline, and even beyond? Rather than being intensively preoccupied with one small body of information, such a person ranges wide and sees the relationships and cross-fertilization potential of one realm of knowledge in respect to another, as did some of the giants of yesteryear. He is competent to engage in interdisciplinary discussion and investigation or to work at the interfaces of his field. He identifies neglected areas of study and encourages other investigators to become interested in them.

In this country we have successfully developed a great number of specialists seeking finer and finer fragments of learning, but in order to direct our nation's resources toward optimum use, a corps of superb generalists is needed to distinguish the important from the unimportant, give continued medical care and supervision, foster good, sound patient-physician relationships, and maintain a reasonable understanding of literature in multiple medical and scientific areas.

How can we broaden the development of these rare and gifted individuals? First, we must develop a more intensive training program for this kind of individual. There must be an upgrading of the image and glamorization of the type of person who can meet these requirements. He should ultimately be capable of applying the best technology of medicine and science to society's most acute social needs. Therefore, he must have a firm background in the humanities and a good understanding of the history of medicine and

science as well as the history of man. He should be able to demonstrate his creativity, for the truly educated man differs from the trained man only in the extent of his creativity.

To generate the process, respect for the superb generalist should be emphasized, and schools at all levels should give standing to the excellent generalists on the faculty instead of rewarding mainly those concerned with the infinitely small. A beginning must be made in reversing this march toward superspecialization; once begun, it will bring forth an increasing number of well-trained generalists who, in turn, will engender others in their own image. In this way, their impact on society, at first minimal, might soon come to be regarded as meaningful.

A second mechanism to help in the much greater quantitative and qualitative delivery of generalization in medicine is better coordination of the efforts of many individuals. Properly done, this team approach can be both effective and economically feasible, particularly if the team captain is a superb generalist. The expansion of team effort, or "group practice," as it is called in medicine, was strongly urged by the President's National Advisory Commission of Health Manpower. The Commission reported that only two percent of doctors choose general practice and that the cost of medical care in the United States will jump two and a half times in the next eight years unless steps are taken to stop the increase. Group practice will not only help solve the apparent shortage of physicians, but will also keep the costs of providing excellent care much lower.

In recent decades we have seen the pendulum swing significantly too far in the direction of the superspecialist's depth rather than the breadth of the generalist. The mandate from the public to ourselves in our devotion to a lifetime of learning suggests that this pendulum should swing back sufficiently to provide the harmonious blending of the two.

CIVILIZATIONAL CONDITIONS OF PROLIFERATIVE DISEASES

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This paper considers the problem of the relations existing between the characteristic civilization of some given population, with ethology (as the science of morals) as its essential component, and the incidence of proliferative diseases of various types, including leukemia.

In different social groups the prevailing cultural patterns are, of course, different and so also are their ethical attitudes. There are, moreover, known geographical differences in the occurrence of proliferative diseases.

The evidence assembled to date is sufficient for us to conclude that in various social groups there must be some specific biological, physical, chemical, and psychosociological factors whose combined action influences the rate of occurrence of one or another proliferative disease.[1, 3, 4, 6–10]

A better knowledge of these factors is of tremendous significance for the healthy development of mankind; such understanding would allow us to identify, utilizing scientific principles of investigation, the pathogenic factors in the environment that cause the excessive rate of particular proliferative diseases and to develop methods for controlling these factors. The effectiveness of the prophylactic measures will, however, depend not only on man's intellectual and scientific effort but also on the degree of his emotional involvement in the attempts to eliminate the pathogens. In other words, the effectiveness of prophylactic measures depends on the mode of action and on the methods used to make real the system of values, which has as its highest aim the achievement of the health of mankind in the broadest sense.

I will, in the following discussion, restrict my consideration of the dynamism of proliferative diseases within a set of ecological conditions to one type only, i.e., to leukemia in men and animals. The working hypothesis may be summarized in the assumption that, because the evidence supplied by epidemiological statistics is already sufficient to demonstrate differences in the rate of occurrence of various kinds of leukemia within the same parameters of time and space, it is now possible to pass to the next stage of research and to identify and check leukemogenic factors by scientific methods. The third stage will then be the control and the elimination of these factors from the environment, i.e., prophylaxis.

Historical Variability of Diseases and Their Dependence on Civilization and Social Structures

Before presenting the current state of knowledge about the forms of leukemia in men and animals in different parts of the world, in different countries, in different districts of a country, and even in limited districts of a town or village, I would like to review briefly the changing pattern of human

diseases in different epochs and different parts of the world. We will see that diseases were influenced by the civilization prevailing at some particular period of history and in particular parts of the inhabited world.

When we look back on the past, we see how each new environmental factor, one after the other, influenced the animals living on the earth. With changing climates, the soil changed, causing, in turn, change of the flora. New environmental factors appearing one by one caused the "variability" phenomena, which shaped the bodies of the anthropoid apes. As the forests disappeared from the surface of the earth, the apes were forced to come down to the ground. New species with erect bodies then appeared. Their further development reflected their way of life, determined by the conditions of their habitat, the open plains of South Africa. The local flora and fauna determined the forms by which these animals satisfied their energy needs. In the glacial epoch of the next stage of evolution, the equilibrium between the living creatures and their environment was dangerously disturbed. Our ancestors died in large numbers of starvation and cold. Only individuals capable of protecting themselves from cold and starvation could survive.

Thus, the appearance of *Homo sapiens recens* depended on the influences of climatic factors, such as the amount of sunshine, humidity, winds, etc. For example, in the course of the lengthy process of adaptation, melanin was concentrated in the epidermis of the human skin and protected the body from the deadly effects of ultraviolet radiation. But before a new morphological type completed its development by adapting to environmental conditions, many individuals must have suffered, and many may have died, from diseases caused by insolation and thus, presumably, also from proliferative diseases.

It, therefore, becomes clear that abiotic factors exerted an influence on the modeling of the human body in the process leading to the development of the particular varieties of the human species. These morphological changes and, hence, the psychological structure of man, depended solely on the random action of natural forces lasting for many millions of years.

It is only when mankind had developed the ability to think and to organize consciously the social environment that the morphological and psychological structure began to change more rapidly.

Because of reconstructions made possible by archeological findings, we can now look back over many thousands of years and with a high degree of probability define the environmental conditions in which diseases developed. The outlines of the history of diseases in different periods and different geographical regions may be traced from the information supplied by the study of preserved human skeletons and by observations of certain primitive peoples, whose way and standard of life, even today, often corresponds to the prehistoric epochs.

The most common diseases of the paleolithic civilization were, according to Jean Bernard, those caused by parasites, as is frequently the case among today's primitive nomad tribes, whose way of life is still governed by archaic social structures. In that distant period, diseases and anemias resulting from food deficiency were not widespread, and men suffered mainly from bacterial and protozoan parasitic diseases, ague, schistostomiasis, etc. Paleontological examinations of 40,000-year-old skeletons show that in the distant past man was not afflicted with deficiency diseases. The nomadic and pastoral way of life and cannibalism permitted him to satisfy his energy requirements sufficiently.

In the more recent past of the neolithic civilization, the important change

from the nomadic to the settled way of life occurred. Men domesticated some animals and learned to select some plants for cultivation. This settled way of life produced special conditions for the development of a new civilization. It was during this epoch that the first signs appeared of social stratification and of groups specialized in particular handicrafts. This, in turn, produced a situation favoring armed conflicts between the tribes. Ever since, wars have had as their consequence hunger and outright starvation. Characteristic for this epoch are such deficiency diseases as the anemias. This is confirmed by neolithic skeletons, which, in their histological structure, show symptoms of dietary deficiency.

We are, thus, justified in presuming that blood diseases, in which various deficiency symptoms were superimposed on the parasitic invasion, were characteristic for the neolithic period. We may, therefore, suppose that the common diseases then afflicting mankind, especially when crops failed, were the counterparts of what today are known as malnutritional disease, kwashiorkor, tropical macrocytic anemia, etc.

Such nutritional deficiencies may have been associated with the disappearance of cannibalism from the territories of Europe and North Africa. This was, however, a critical period, and mankind, having passed through an all-important revolution, reached a turning point in its moral history.

It seems highly probable that in the distant past men also suffered from proliferative disease of various types; they could have been exposed to such natural oncogenic factors as 3,4 benzpyrene, which sometimes was excessively concentrated in the vicinity of asphalt deposits near volcanoes, or telluric radiation. Nevertheless, these factors must have been incomparably more rare than they are today, when the chemical industry is developing increasing numbers of new products with mutational, teratogenic, carcinogenic, and leukemogenic effects.

Contemporary civilization has been dominated during the last two centuries by the industrial revolutions, which have changed the pattern of prevailing diseases. Progress in hygiene and the growth of the pharmaceutical industry have undoubtedly limited parasitic infections and the advance of factors causing nutritional deficiency diseases. Appearing in their place today are diseases caused by the toxic effects of industrial by-products that often possess carcinogenic properties. Technical civilization, which represents man at a definite stage of his evolution, brings with it both favorable and unfavorable conditions for his further development. It has made possible the suppression of the epidemics that harassed mankind for centuries. It has added many years to human life. By reducing infant mortality, it has produced, along with highly desirable effects, a new demographic explosion and its concomitant alarming economic and social consequences.

Thus, the contemporary epoch is characterized by a steady growth of the number of tumors, exceeded in the developed countries only by premature death from arteriosclerosis, heart disease, and traffic accidents. Tumors and leukemias, which, during the first decades of this century, were not observed in young people and children or in animals and fish, have become much more frequent.

All these observations lead to the conclusion that the extremely rare occurrence of proliferative diseases in the primitive civilizations was due to man's very limited exposure to a very limited number of oncogenic factors. Today, our industrial civilization increasingly exposes man and the higher vertebrates

to carcinogenic and leukemogenic factors that accumulate in the environment. They disturb the biocenotic equilibrium, a fact becoming increasingly obvious in the particular links of the water-soil-plant-animal-man chain.

As can be seen from the above discussion, the kind of social structure characteristic of the particular stages of historical evolution, i.e., considered in relation to time, determines the occurrence of specific proliferative diseases. Any change of the social structure obviously leads to change in the environment and, in turn, in the manner that proliferative diseases afflict humanity.

Contemporary Regional Differences in Proliferative Diseases and Their Incidence

R. Doll has published maps showing the worldwide distribution of cancers of the esophagus, stomach, lungs, colon, breast, and liver.[5]

It appears that cancer of the esophagus has three main high-incidence foci: Kazakstan on the northern coast of the Caspian Sea, Bulawayo in Southern Rhodesia, and the region of Transkei in South Africa.

Comparison of esophageal cancer occurrence in various countries shows that in the Guryev district in Kazakstan, its incidence is 200 times higher than in the Netherlands and Nigeria. This phenomenon has not yet been satisfactorily explained. Burrell and co-workers have suggested that the factors responsible for these differences lie in a deficiency of certain soil components and the infection of crops with substances causing the production of nitrosamine.

Cancer of the stomach is most frequent in Japan, the U.S.S.R., South Africa, Chile, and Colombia. Its incidence is particularly low in southwest England and among the white population of the U.S. Such a distribution is attributed by various authors to dietary factors. Associating this form of cancer with substances in decaying foods, they suggest that improved methods of preserving food that are widely applied in the United States determine its low incidence of stomach cancer.

Lung and bronchial cancer is most common in Great Britain, Central Europe, especially Germany, Belgium, Czechoslovakia, Hungary, the Soviet Union, Canada, the United States, Uruguay, and New Zealand. On the other hand, in Spain, France, Italy, Yugoslavia, Romania, and the Balkan States, it is less frequent. Men are more often attacked than women, except in Great Britain, where women patients are more numerous.

A remarkable property of cancer of the large intestine is its apparent association with the Anglo-American way of life and not with race. It is equally common among white and black. Its occurrence is very low among the African population of South Africa and in the Balkans, India, the Philippines, and Japan.

The incidence of breast cancer is highest in the countries of western Europe, South Africa, Australia, New Zealand, and Israel. The further east, the lower the incidence of this disease; it is very low in Uganda and Mozambique, Taiwan, and Indonesia. In the U.S., the rate of the disease among white and black women is the same. Japanese living in the Hawaiian Islands suffer a higher breast cancer incidence than those living in Japan.

The data on the distribution of cancer of the liver refer to man between the ages of 15 and 44. This age group was chosen for observation because in countries with an especially high incidence of hepatic cancer, it appears earlier in that age group. Another reason for choosing this age group was that it ensured the fewest diagnostic errors, because in older persons it is often difficult to distinguish between primary cancer of the liver and cancer of the biliary ducts.

It appears that in this age group hepatic cancer is rare everywhere in the world except in some areas in Africa: the province of Ibadan in Nigeria, Johannesburg, and Mozambique, where it occurs as frequently as lung cancer in Great Britain and is more than 1,000 times higher than primary liver cancer in various parts of Europe. It is believed that aflatoxin, a metabolic product of *Aspergillus flavus*, is responsible for the high incidence of hepatic carcinoma. This mold develops with special abundance on such substrates as groundnuts and foodstuffs kept in a damp and warm environment.

Lymphatic leukemias in men and animals are extremely rare in China and the Far East, a fact pointed out to me during my visits in 1960 to the clinics and hospitals of Peking, Ulan Bator, and Canton. On the other hand, in the Netherlands and the countries bordering on the Baltic Sea, i.e. Denmark; Schleswig, West Germany; and the Polish northern provinces, morbidity from lymphatic leukemia in both men and cattle is particularly high.

Studying morbidity from leukemias in cattle in Poland, Karaczkiewicz found that the rate was very high, sometimes higher than 200 per 100,000 in the northwest provinces, although in the southwest provinces it was as low as about six per 100,000. The geographical difference between these high and low rates of leukemia incidence in cattle corresponds to the partition boundaries between the parts of Poland, which before 1918 were attached to Germany on the one hand and Austria and Russia on the other. According to Karaczkiewicz, this remarkable epidemiological situation was caused by the differences in agricultural techniques in the partitioned parts of the country. It is common knowledge that agriculture was more advanced in Prussia than in the other two partitioning countries; potassium fertilizers were used in much greater quantities, which led to the reduction of the magnesium content of the soil, thus disturbing the biocenotic balance in a direction that favored the proliferative processes in tissues, a problem I shall deal with below.

Cultural and Industrial Causes of Proliferative Diseases

The problem at this point is to find an explanation for the differences described above in the geographic distribution of cancers. Recent epidemiological research has proved that morbidity in the proliferative processes depends to a much higher extent than previously supposed on man's conditions of life. For this reason, nearly 90 per cent of cancers are today believed to be stimulated by human activities, and thus, theoretically speaking, it lies in man's power to prevent them.

Some authors, for instance Higginson, classify cancers according to the nature of the precipitating factors into cultural cancers, industrial cancers, and idiopathic cancers.

The first of these groups are the cancers that may be attributed to traditional customs of a particular population. For example, in India, oral cancer is common, and the cause, in the Bombay region, is the custom of chewing betel leaves. A small piece of the betel leaf, which has narcotic properties, is placed in the mouth between the tongue and the cheek. The leaves are pow-

dered with lime, which causes congestion of the mucous membrane of the mouth, thus improving assimilation of the drug. It is not surprising, therefore, that cancer of the mucous membrane of the mouth is a common disease among these people.

In South Africa, similarly, there is a custom of using snuff made from the leaves of the aloe plant, and this seems to be the cause of cancer of the sinuses.

It is now well known that among cigarette smokers, lung cancer is two to three times more frequent than cancer of the mouth. On the other hand, among peoples where there is a custom of using *naswayam*, a mixture of tobacco, ash, lime, and oil, independently of cigar and cigarette smoking, cancer of the mouth is twice as frequent as lung cancer. In the Kashmir, a common form of cancer called *kangir* develops on the skin of the abdomen; among the peoples of this area, there is, reportedly, a custom of warming the abdomen with a lump of hot clay.

Our second grouping, industrial and occupational cancers, includes asbestos tumors that occur in workers living near asbestos deposits or working in asbestos mines. In South Africa, mesothelioma caused by irritation with chrysolite frequently occurs. Arsenic compounds, to which farmers are often exposed because of the extensive use of pesticides and insecticides in modern agriculture, are also responsible for a substantial proportion of lung cancers.

Case reported that naphthylamine used by the textile industry for dyeing fabrics caused tumors of the bladder in 15 workers employed as distillers. He concluded that everybody was susceptible to exposure to carcinogenic factors when their dose was sufficiently high.

Finally, it is a well-known fact that leukemia and erythroleukemia occur among persons working in a benzene-contaminated environment.

In the last group—idiopathic cancers—Higginson lists different forms of cancer for which an etiological background could not be identified with research methods existing at present.

Ecological Conditioning of Etiology and Pathogenesis of Proliferative Diseases

The evidence presented here to prove both quantitative and qualitative differences between various forms of proliferative disease in various cultural formations seems also to indicate that there must be differences of concentrations of the known and suspected carcinogenic and leukemogenic factors within the particular ecological environments. In an attempt to obtain a clearer picture of these factors, we undertook a group of investigations of small areas, such as districts, towns, and villages, and even individual farmsteads and houses, together with the environment in the homes of cancerous marriages and families.

These studies showed that in specific areas there were centers of cancerous and leukemic diseases and that their distribution was not accidental but was determined by specific factors. In order to show more clearly to what extent environmental conditions, shaped by man himself to a much greater degree than by the forces of nature, are responsible for the spread of proliferative diseases, I shall outline here the present state of knowledge about oncogenesis.

For the development of a proliferative disease, the following hypothetical

conditions must be fulfilled: (1) predisposition, (2) presence of the virus infection factor, and (3) presence of cocarcinogens. Predisposition consists of a set of biological phenomena occurring at the molecular level of the genetic structure. It is precisely these phenomena that are responsible for the fact that in the same environmental conditions some persons are attacked by proliferative disease, which suggests a predisposition, whereas others are not.

The differences in predisposition are due to deoxyribonucleic acid (DNA), which carries the structural, and hence the metabolic, code of cells and determines that the daughter cells have the same structure and functions as the parent cells.

The genetic system and the molecular structures of cells are weakened with regard to lysosomes and genes by the absence of some stabilizers, of which so far Mg^{++} ions have been identified, a result of the work of Goldberg and others. A deficiency of Mg^{++} ions facilitates penetration of the genetic structure of cells by viral oncogenic factors; these factors then cause the uncontrolled multiplication of cells, resulting in proliferative growths. Among the carcinogens, the best known are ionizing radiation, some chemical compounds, and mold metabolites and are referred to by the general terms of physical, chemical, and biological cocarcinogens, respectively. Under specific conditions these cocarcinogens activate the nucleic acid molecule, which probably has the same nature as a virus and causes a structural change in the genetic apparatus of the cell. This disturbs the daughter cells and makes them form a clone that differs in structure and function from the parental cells and assumes the form of neoplasmic growth.

This viruslike factor, the particle *C*, as it has been called, has now been identified by electron microscopy by Dmochowski and others. The particle *C* seems to be responsible for the vertical and horizontal transfer of the proliferative disease from experimental animals to animals with a specific immunological structure, from man to animals,[11,12] from one farm animal to another, an occurrence often observed in agriculture, and perhaps from animals to man. In this last case, the direction of the transfer is indicated by some results of prospective experiments to which, of necessity, we have to restrict ourselves.

The aim of our ecological researches—I present here only one of the investigated cases—is to identify the environmental factors that may, in the present state of knowledge, be responsible for oncogenesis due to mutual infection or to exposure to conditions having an oncogenic effect both on men and on animals.

We conducted our investigation,[2] in collaboration with professors of agriculture, University of Krakow, Ewy, Litynski, Komornicki, and Smyk, in the village of Okocim-Pomianowa. In this village there was a "cancerous" house where five persons, three of them relatives, suffered from cancer. Adjacent to the house was a cow shed where for years the cows had had leukemia (leukemia herd). The farm was an experimental one belonging to the School of Agriculture in Krakow. This environment was very suitable for ecological studies on oncogenesis.

We found that in the farm there was (1) a reservoir of oncogenic viruses in cows with leukemia, (2) a reservoir of biological cocarcinogens from molds producing carcinogenic metabolites, i.e., *Aspergillus flavus, Penicillium meleagrinum*, and *Rhizopus nigricans*, in the walls of the "cancerous" house, barns, and soil, and (3) a magnesium deficiency in the Uszwica River, in the soil, and in the wells (TABLE 1).

TABLE 1

Water and Soil Contents of Two Farms

	Water *					Soil	
Farm's Name	Ca^{++}	Mg^{++}	K^{+}	Fe^{+++}	SiO_2	Mg^{++} in mg/100g	pH
Pomia nowa	53.9	6.9	12.9	0.4	16.0	2.0– 7.0	±5.6
Radlow (control)	67.5	46.5	3.5	11.2	4.0	10.0–28.0	6.0–7.0

* Mean value from May and October, 1969, in mg/1,000 ml.

We have recorded many similar examples where the presence of molds from the group of *Aspergillus flavus* and *Penicillium meleagrinum* and the Mg deficiency in the soil were confirmed in the environment of leukemic and cancer patients.

In the next environment in which the incidence of proliferative diseases was significantly higher, we made the following observations:

In the village of Liszki, about 20 km to the west of the city of Cracow, 14 cases of various neoplastic diseases were reported in the years 1964–1968 (I. Gajda), i.e., an incidence of 180/100.000 annually. The incidence rate of the Cracow province in these years was 136.63. Mapping of the households inhabited by the patients showed that 11 houses were situated within a radius of 250 meters of the house where the first case of neoplastic diseases occurred (K. Janicki). This distribution is statistically significant on the basis of the chi square test with Yates' correction, because theoretically the expected number of cases in the area under consideration is 3.35, and 10.65 outside of the area. The empirical number of cases in the area exceeded the theoretical number threefold. Hence, this tumor "cluster" is statistically significant.

After the termination of this study, in 1970 two new cases of lymphoma occurred in humans inhabiting the foregoing area and no new cases in the remainder of the village. The age of the patients ranged between 23 and 67 years. There was no evidence of family predisposition.

Water from all four wells in the area inhabited by the patients was found to have high contents of K, SiO_2, and very low content of Mg, Cu, Fe. The Mg/Ca ratio was many times lower than in water from a control farm in Radlow situated about 60 km away in a straight line, according to assays at the Chair of Pedology (Prof. Komarnicki). TABLE 2.

The Provincial Agricultural Chemical Station reported high acidity (pH 6.4–6.7) of soil from the area, low values of Mg and Cu. Other microelements were not studied. Fungi imperfecti were cultured from the dwellings of the patients. The five most frequent fungi producing mycotoxins known to possess carcinogenic properties (verified at the Chair of Prof. Smyk) obtained were: *Aspergillus flavus, Penicillium meleagrinum, Cladosporium herbarum, Rhizopus nigricans* and *Alternaria geophila.*

Because the magnesium ion acts as a stabilizer for ribosomes and for the genetic systems (Goldberg, West, and others), and as an activator of RN-ase and the properdine system protecting the cell against invasions of oncogenic viruses and action of mutagenic factors, we hypothesized that feeding the

animals a diet deficient in Mg would favor oncogenesis. This hypothesis was confirmed by the work of McCreary, Battifora, and P. Bois, and, in Poland, by Kowalczykowa and Stachura, who caused leukemic proliferation in rats fed Mg-deficient diet.

The experimental results suggest the hypothesis that in countries in which dietary magnesium is high, the incidence of leukemia should be low. This is confirmed by Seelig, who reported that in the Far East, where leukemia in cattle and lymphatic leukemia in men were rare, the daily dose of magnesium was 6–10 mg per kg food. On the other hand, the daily dose of the Euro-American population is less than 5 mg of magnesium and is steadily dropping.

The level of magnesium in soil is determined by the contemporary cultural pattern; modern agricultural techniques are dominated by potassium fertilization; because of the magnesium-potassium antagonism, the magnesium content of soil, and therefore of plants, animals, and men, is steadily reduced.

* * *

In contemporary civilization, the dominant pattern of interhuman relations is characterized by malnutrition of two-thirds of the inhabitants of the world; therefore, the use of chemical compounds for more intensive farming and higher agricultural output is justified, even if it leads to a disturbed biocenotic balance and, consequently, to—among other problems—proliferative disease caused by overuse of chemical fertilizers. The logical consequence of this situation should be, however, such interhuman and international relations that would allow man to preserve the biocenotic equilibrium, thus acting prophylactically to prevent the spread of proliferative diseases.

It remains to be seen whether the attempts to correct the supply of magnesium and probably copper, iron, etc., in soil, water, and plants, will reduce the incidence of proliferative diseases in the districts where the deficiency of these elements and proliferative disease morbidity are high.

In sum, we present the opinion that one of the most important ways to prevent neoplasm is by protection of the balance in biocenosis; it means a conservation of nature. Conservation of nature is conditioned by war prophylaxis. It is obvious that in some situations, war industry pollutes water, soil, and food with carcinogens destroying the biophysical environment considerably more strongly than would industry without military purposes. Hate, fanaticism, and racism are ruining the psychosocial environment connected

TABLE 2

MICROELEMENTS IN WELL WATER IN CLUSTER OF HUMAN CANCER IN LISZKI VERSUS CONTROL IN RADLOW

	Mg^{++}	Ca^{++}	Ca/Mg	SiO_2	Fe^{+++}	Cu^{++}	$K^{+}Na^{+}$
Liszki well 1	42.2	321.6	7.62	26.0	0	0.022	292.7
" " 2	36.2	162.2	4.46	22.0	0	0.009	496.8
" " 3	51.3	260.9	5.08	20.0	0	0.009	388.5
" " 4	30.2	200.1	6.62	32.0	0	0.009	396.9
Radlow well central	46.5	67.5	1.45	4.0	11.2	—	26.5

with the biophysical environment. In this way, the vicious circle devastating human kind is being closed.

We believe that the human being—the highest value—creates new values and is dependent on them. So, the fate of humanity in our own hands.

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Physical Sciences and Engineering

Francis Perrin, *Chairman*

Walter A. Rosenblith, Arne Tiselius, *Cochairmen*

Perrin: Before inviting the scheduled speakers to address the third plenary session—on the development of the physical sciences and engineering—I would like to take a few minutes to summarize the main conclusions of my own written paper, and I will focus on the problems of pollution connected with the production of energy.

We must first recognize that energy is the single most significant factor in the development of modern civilization and in raising the standard of living in the advanced countries; an increased understanding, production, and utilization of energy is the essential key to raising the standard of living in the underdeveloped countries. Heat energy is used either for warming of dwellings or for power in industry. Energy provides motive power for cars and for motors in industry; it is distributed in the form of electricity, which is the most versatile form of energy from which heat, light, and chemical energy can be produced.

We must expect an increase in the demand for energy both in advanced countries and in underdeveloped countries. During the past 50 years, energy consumption in the world has been increasing at an exponential rate. Electric power consumption has multiplied by two every 10 years during the past 50 years—meaning, therefore, a multiplication of electric power production by a factor of more than 30 during the past 50 years. And there is no indication of any reduction in the need for and the production of electric power.

In advanced countries like the United States, the concentration of electricity has been so great that a point of saturation was expected in past years, but it has not yet occurred. So we may expect that even in advanced countries, an increase in the consumption of electric power will continue at the same rate at least for one or two periods of doubling, that is, within the next 10 to 20 years.

In the developing countries, the consumption of electric power is much lower per capita but increases even faster—at least in those countries, such as India, which have begun industrial development.

By 1990, the world use of electricity will be four times larger than it is today. Total consumption of energy—meaning, essentially, electricity plus heat—is growing less quickly because the consumption of heat in industry and private homes is multiplied by two only about every 25 years. We may expect, therefore, that in the year 1990, there will be a multiplication by three of the total energy consumption in the world. And, in the year 2000, we can look forward to a multiplication up to a factor of six.

At that time the world's population will probably be double its present level. So a future holding a fast-increasing demand for energy—mostly electric energy—within the next 20 or 30 years is likely. And we know that there is no other possibility of raising the standard of living in the underdeveloped areas than by helping to increase energy consumption.

To satisfy this demand for energy, mankind must use the primary sources of energy, which are the only ones that will have much importance before the end of the century: hydroelectric power and fossil fuels—coal, oil, and

natural gas. And, since the discovery, some 30 years ago, of nuclear fission, mankind also has the option of using nuclear energy.

New hydroelectric power stations will contribute only a small fraction of the world's total energy requirements. Fossil fuels, which must be burned to produce energy, either heat or electricity, present problems; it is possible to foresee an exhaustion of fossil-fuel reserves within a century or two. Much before total exhaustion, there would be a scarcity, perhaps before the end of this century; this would mean rising costs of electricity and of heat, which would, in turn, mean it would be impossible to raise the standard of living in underdeveloped countries as fast as is necessary. Within two generations, there would begin a decline in the material condition of mankind.

The discovery of nuclear energy changes this future completely. There are unlimited reserves of very poor ores, such as ordinary granite, that contain a few parts per million of uranium; with use of breeder reactors, the total amount of energy that we will be able to produce from uranium is so great that it does not matter if we have to pay ten times more than we now pay for uranium from rich deposits. With breeders there is no possibility of any scarcity of energy in the future. Without breeding, however, the cost of power production by nuclear energy would increase before the end of this century, and there would be concomitant exhaustion of the rich uranium deposits well before the middle of the next century. But with breeder reactors, which should become competitive within 10 or 15 years, there is no such problem of exhausting uranium ores; for many millions of years to come, mankind will have the ability to produce, let us say, 100 times more energy than it is now using.

I would like to summarize the considerations of pollution associated with the production of energy. There is no pollution from hydroelectric power stations. But, as I said, this is a quite limited source of power. Fossil fuels must be burned for energy production, and this means very serious pollution of two types. From power production in large electrical stations, the main pollution comes from the sulfur impurity in the natural fuel. This may be very serious in the future. The content of sulfur in fossil fuels is very different from one source to another. There are certain coals that have little sulfur, and these could be used, of course, to produce power in populated areas. There are also some oils produced that contain little sulfur, but, in general, small percentages of sulfur are responsible for large amounts of contamination.

It is impossible to desulfurize coal, so this fuel should be burned only far from densely populated areas; it is the same for heavy fuel oils; they cannot be desulfurized or will be very expensive to desulfurize. Light fuel oils, such as, for instance, for automobiles, may be desulfurized to avoid contamination by sulfur dioxide in cities. And it is possible to desulfurize natural gas; the sulfur then has a value of its own. Nevertheless, if we had to support all production of electricity by natural fossil fuels, we would have very serious problems of sulfur dioxide pollution.

In a nuclear power station there is practically no radioactive pollution of air or of water when the station is in normal operation. Only following an accident may there be some contamination. In the case of a small accident, any contaminated water would be retained in special tanks and released into the river or the sea after purification or the decay of radioactivity according to very strict regulations. So there is no problem. The air contaminated by fission products, in case of a small accident, could be contained in an airtight building around the reactor and released into the atmosphere through special charcoal filters, which would control fallout, and only radioactively inert gases would be dissipated in the atmosphere through high stacks. This would mean no radioactive fallout.

In the case of a major accident with destruction of the reactor and of the reactor building, which is very unlikely, there might be radioactive fallout in the neighborhood within a few miles, perhaps 10 miles of the power station. This fallout would not even, in the case of such a major accident, imply immediate danger for the inhabitants of the area surrounding the power station. But it might lead to their evacuation for a more or less long period. It is because of the difficulty, cost, and hazards of evacuation of a large population that nuclear power stations should not be situated in densely populated areas.

But we must remember that when large, fast-neutron power stations of more than 1,000 megawatts are in operation, which will be a necessity for extensive use of atomic energy within 20 years, the possibility of a major accident will be of much greater concern because of the large inventory of plutonium in such reactors. Because of the high radiotoxicity of plutonium, it would be wise to situate powerful breeders in areas with little or no population living within a distance of, let us say, 10 miles. But this is not a serious objection or valid reason to refrain from using such breeders on a large scale, because it is and will be more than economical to transmit large amounts of electric power at very high tension up to 1,000,000 volts along distances up to 1,000 kilometers. It is already economical, costing just a few percent of the price of the power transmitted. It should be possible with just a small increase in the cost of power to situate these large breeders in lightly populated areas.

There is also the question of radioactive waste from the reprocessing of nuclear fuels. These are usually dumped as concentrated solutions in large, double-shell, stainless-steel tanks. This is safe enough for the time being, but later, when there are large amounts of such fission products, it will be necessary to use more elaborate methods of dumping, which have already been devised and which will only slightly increase the cost of production of electricity from nuclear energy.

So-called thermal pollution is not a very serious question. Thermal pollution of rivers is merely a limitation on the total power that can be produced by the power station along such rivers; this limitation is not very serious because we can use towers to cool the condensers by evaporating water, so there is no major thermal-pollution problem.

As a general conclusion, I would say that a scarcity of fossil fuel will undoubtedly appear in the rather near future. And this can be avoided only through the use of nuclear power—nuclear energy—and this is of fundamental importance for the distant future of mankind.

For the near future, nuclear power stations for generation of electricity are becoming economically advantageous, at least in certain regions of the world; this has led to the rapid development of nuclear power stations, essentially in the more advanced countries. Utilization of nuclear power will help solve the problem of atmospheric pollution during the next 10, 20, or 30 years, and this new source of power will also be important, although later, for the developing countries.

The first paper today will be by Dr. Ernst Bergmann, and he will be followed by Dr. Jacob Feld.

RECENT ADVANCES IN CHEMICAL SCIENCES

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To be a prophet is a thankless task, even for an Israeli—although Israel has been the land of the prophets. Especially in science and technology, it is probably more reasonable to extrapolate into the future existing knowledge, trends of development that characterize the present. One may then be faced with the possibility that a "breakthrough" will upset the forecast and the planning; however, the history of science appears to teach us that breakthroughs are rare indeed and that, on the whole, there is an inherent logic in the development of science and technology.

Methodology. The period in which we live is characterized by a weakening of the delineation between the various scientific disciplines. As far as chemistry is concerned, we are witnessing on one hand an increasing influx of mathematics and physics into the science of chemistry in the classical sense and, on the other, an expansion of chemistry into the life sciences. The meaning of "molecular biology" is, in fact, only the transfer of certain areas of biology into chemistry.

The mathematical methods of quantum chemistry have been so refined and the use of high-speed computers so perfected that it is almost a routine task to calculate the physical and chemical properties of known inorganic and, especially, organic molecules and to predict the properties of molecules that have not yet been prepared by the chemist. Of particular interest is the application of these methods to molecules of biological importance; it has very recently become possible to calculate the various *conformations* of biologically active compounds and to determine the relative energies of such conformations.

Physical methods of analysis have made it possible to detect quantities of chemical compounds several orders of magnitude smaller than hitherto. I am referring to such methods as nuclear magnetic resonance and mass spectroscopy, on one hand, and to the chromatographic methods, on the other. It has recently been shown, for example, that we can make a quantitative analysis of the purine and pyrimidine bases of the nucleic acids of a single brain cell by chromatography on a quartz fiber.

Computers make it possible not only to supervise industrial processes "on stream" and to operate a factory almost without human labor but even to design, in the most rational way, complex chemical syntheses. Corey has recently given a most impressive example of this possibility by applying it to the synthesis of patchouli alcohol.

As for the expansion of chemistry into biology: in the past we explored mainly the bulk constituents of cells, e.g. proteins, sugars, and lipids, but we are now engaged in the elucidation of the structure of those compounds, which are so enormously active that the cell needs them only in minute quantities. Here, of course, the modern methods of analysis that we have referred to are of extreme importance, especially because many of them are of nondestructive nature. The study of enzymes, vitamins, and hormones has thus become a

chemical rather than a biological activity. Let us mention here the elucidation of the complete structure of the enzymes lysozyme and ribonuclease or the isolation and identification of the insect pheromones, which belong to the most active compounds known: the pheromone of the female silk moth (hexadeca-*trans*-10-*cis*-12-dien-1-ol) is active in quantities of 10^{-10} micrograms, so we may well suspect that only one single molecule may be necessary for the biological effect.

Within chemistry itself, the classic distinction between organic and inorganic chemistry has become blurred. This is because of the rapid development of the study of organometallic substances, which not only are of considerable theoretical interest but appear to have many practical applications. In particular, homogeneous catalysis of many reactions has thus become possible, such as hydroformylation, decarbonylation, hydrogenation, and dehydrogenation, or isomerisation of unsaturated hydrocarbons. Perhaps most spectacular is the ability of certain of these organometallic complexes to bind molecular nitrogen (in the same way as the isoelectronic carbon monoxide) and thus to permit nitrogen fixation in a manner that might well prove to be a model of the method employed by nature. Another example of such "hybrid" chemicals is ferrocene, which is the parent substance of a whole series of interesting "pseudoaromatic" substances.

Raw Materials. Before the end of the century, we will apparently be faced with the fact that the raw materials on which our present technical civilization is based have gradually been exhausted. This is true for the ores we are exploiting, and even more for the fossil fuels we are employing both for our machines and as the starting point for the petrochemical industry. We will thus be forced to utilize poorer ores than those presently mined, and we will have to develop methods for the enrichment of the important constituents of such poor ores without greatly increasing the price of the final products. On the other hand, we will have to develop to a greater extent synthetic materials that can replace the fundamental materials we use, even for construction; this will be an additional burden on the petrochemical industry, which today is the main source of synthetic products.

There is, however, one area that may yield large quantities of ores, viz. the ocean, and it is likely that chemical and industrial oceanography will attract increasing attention in the future.

Whatever the outlook for new sources of fossil fuels may be, there is no doubt in my mind that we will gradually abandon such fuels as the source of energy, so that more and more of our present resources can be made available for the petrochemical industry. Even so, the amount of crude oil and natural gas is finite, and the question will arise: is there a raw material that is available at least in the same quantities as natural oil and gas or, if possible, in really unlimited quantities? It would seem that there is only one such possibility that can be taken into consideration, and that should be explored even if it appears unusual at first sight. One can transform, by fermentation, carbohydrates (sugar, starch, cellulose) into chemical compounds containing two, three, or four carbon atoms and thus equivalent to the fundamental substances, ethylene, propylene, butylene, isobutylene, and butadiene, which the petrochemical industry produces by cracking and then transforms into its final products.

The scheme in FIGURE 1 gives an idea of these possibilities.

The sugars from which this scheme starts are indeed available in unlimited

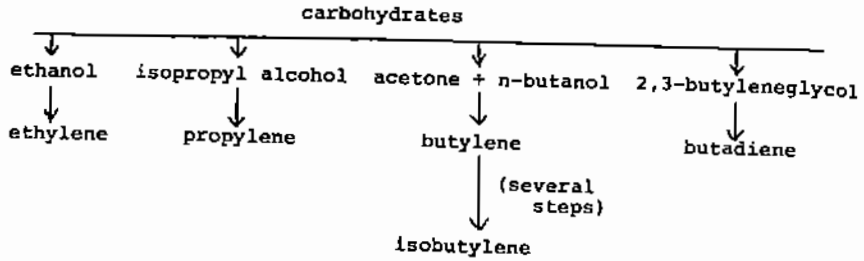


FIGURE 1. The fermentation of carbohydrates.

quantities because they are reproduced by nature year after year. We would have to learn to look to agriculture and the fermentation industry as an alternative to the cracking industry. The implications of such a change of view are obvious: they may be of particular importance to the planning of the developing countries in the tropical and subtropical areas of the world and therefore capable of producing large quantities of carbohydrates in various forms.

Naturally, this approach to agriculture not only from the point of view of food production but also from that of industry is by no means new. The utilization of agricultural products, including agricultural wastes, for industrial purposes has been and still is one of the foundations of the chemical industry. However, it might be useful to consider that, from a more philosophical point of view, the proposed scheme (for which the name chemurgy was coined during the Second World War) is highly satisfactory. Our machines burn fuel to carbon dioxide, which is also the end product of the oxidation of food in our body. Carbon dioxide is assimilated by plants and transformed by them into sugar. In prehistoric periods, geological processes converted plants into fossil fuel and thus created a potential cycle that no longer exists. The fermentation of carbohydrates produced by plants creates a bypass to this blocked cycle and thus re-establishes the economy of nature. This is indicated schematically in FIGURE 2.

In general it can be foreseen that biotechnology will become a major constituent of the chemical industry. As examples, I would like to mention the production of glutamic acid by fermentation of sugar in the presence of ammonia, the technical synthesis of lysine by a mutant of *Corynebacterium glutamicum*, or the use of various microorganisms to modify the structure of steroids to give them higher biological potency than they have in nature or to induce biological or therapeutic effects previously unknown. Perhaps one can expect that similar methods will become available by the use of tissue cultures for the modification of chemical substances of biological or industrial importance.

I would like now to refer to a number of areas in which the chemist will be faced with new and, to some extent, urgent problems that will have to be solved in the near future.

Food Production. If we assume that at the end of the century the population of the globe will be of the order of 6 billion, larger areas will have to be made available for food production. This will be possible only if we extend agriculture to the vast desert lands that are not utilized today. The problems

of plant physiology (and physiology in general) under desert conditions will thus become a major objective of research, and we will have to extend our knowledge of and experience in applied genetics to adapt useful crops to the conditions of arid zones. Let us recall that the breaking of the genetic code has opened many avenues to such unknown fields as adaptation to "unnatural" environments.

Whatever the outcome of this research, two predictions can be made safely, namely, that the fertilizer industry will see an unprecedented growth and that we will have to solve the problem of seawater desalting. Water is such an essential commodity that economic considerations will have to take second place in the planning for this important area. The combination of nuclear reactors and reverse osmosis on a very large scale will be the most practical solution of the problem, if we can find an answer to the chemical question of how to produce membranes sufficiently active and mechanically stable for this purpose.

This is not to say that other methods to increase water supplies will not be investigated, among them the recovery of used water, more economical methods of crop irrigation, the avoidance of excessive evapotranspiration, and, of course, artificial rainmaking by cloud seeding.

The most important problem in food production is that of protein supply. Today, one can define developed countries as those in which protein is the nutritional mainstay and underdeveloped ones as those in which starch plays the central role in nutrition. Furthermore, there exist in many areas of the world religious reasons for not utilizing animal protein. In any event, new methods of protein production must be discovered. Only recently, processes for the production of protein from crude oil by certain bacteria or the production of protein by algae have been developed, along with that of protein-rich meal from fish that are not fit for human consumption. In any event, present methods of production of meat, namely the feeding of plant protein (mainly industrial-waste protein) or the products just mentioned, to animals and its recovery as meat or other animal products permits a utilization of the protein

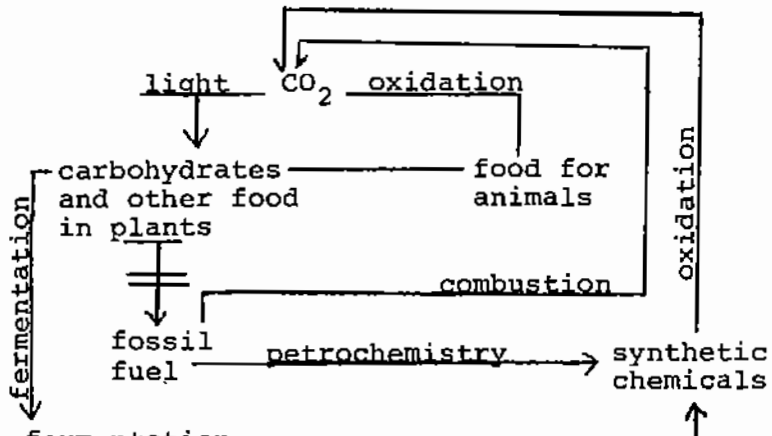


FIGURE 2. The fermentation of plant carbohydrates.

nitrogen in the order of magnitude of only 10 percent. On the other hand, there is, perhaps for genetic reasons, a fundamental difference in our ability to assimilate and utilize vegetable and animal protein: the former generally has not the amino acid composition that we find in animal products, and its enzymatic hydrolysis in the body is less easy and less complete. One can, therefore, predict that we will have to have recourse to hydrolysates of vegetable proteins (which obviate the difficulties of enzymatic digestion) and to the enrichment of such hydrolysates with synthetic amino acids.

A second, not less important, problem is that of food preservation, which is most urgent in the countries with high average temperatures. We will witness rapid development of the methods of food irradiation that have shown such outstanding results in the preservation of potatoes, onions, some fruits, fish products, and the like. No doubt a certain resistance to such irradiated food will have to be overcome by a more reasonable appreciation of the advantages of this procedure.

Insect Control. In the field of insect control we are at present witnessing an even less rational approach. There is no doubt that the use of chemical insecticides has disadvantages and creates dangers, but against this we have to weigh the advantages that these chemicals have given the human race in its fight against insects; let me mention only the control of malaria by DDT. We have to reckon with the fact that insects gradually develop resistance to the insecticides we apply so that we must use larger quantities of the known compounds or develop new ones that are more toxic and not only to insects. New methods will have to be developed, and it is rather surprising to realize how little we know about the chemistry and biochemistry of those insects with which we have lived in an uneasy symbiosis for so many thousands of years. Several new methods, I believe, will emerge. The first will be the rational utilization of the sex attractants (pheromones) of insects, and it is gratifying to see that for a number of insect species these highly active compounds have been isolated, identified, and even synthesized.

A second important possibility is the sterilization of insects by ionizing radiation or chemosterilants. This method has not been utilized as fully as it deserves; it shares with the application of pheromones the feature that it applies only to an individual species and therefore will upset the equilibrium in nature only to a minimal extent. Third, if we can find a characteristic step in the biological processes in insects that has no counterpart in higher animals, we may be able to develop a "magic bullet," in the sense of Paul Ehrlich, that will interfere with this specific process. Although on the whole the biochemistry of the insects is not very different from that of higher animals, there are indications that our search will not be in vain. One observation seems to me of interest in this respect, namely, that insects require cholesterol for their development but are unable to synthesize it themselves.

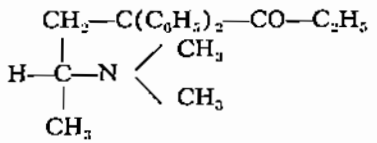
Pollution of the Environment. Here again we will have to arrive at a less emotional approach to the problem before we can look for a solution. The question is obvious: What are we willing to pay for the comfort of modern society? It seems to me that the use of atomic reactors will greatly reduce the amount of air pollution and that we will soon see cars run on electricity instead of liquid fuel. However, the chemical industry will also have to modify its processes, even if its products become more expensive. This applies not only to industrial wastes but also to what I would call societal wastes—namely, packaging materials. In spite of recent suggestions, there does not yet exist a proper solution

for the question of what to do with the vast amounts of packaging materials employed today by modern society, apart from plastic materials, especially glass and metal. Perhaps we will have to renounce completely the use of inorganic packaging materials.

Medicinal Chemistry. Undoubtedly the field of drug research will continue to attract the attention of the organic chemist. Already a rather empirical approach is being replaced by a more rational one, for the design of active molecules on the basis of a reasonable mechanism for the process that the drug is intended to inhibit. This "chemotherapeutic" approach, an outcome of Ehrlich's original model of drug action, has found its justification in the development of the sulfa drugs. Another example is the antimetabolic action of certain organic fluorine compounds, such as fluoroacetic acid or 5-fluorouracil, which are antimetabolites to the corresponding natural hydrogen compounds. In this case, it appears that the antagonistic action is based on the great similarity in size of the fluorine and the hydrogen atoms, between which the living cell is not always able to differentiate.

The general approach to medicinal chemistry is thus to find the relationship between chemical structure and activity, chemical structure including the spatial structure of the substances. We are looking for the structure of the active site of enzymes or of the chemoreceptors on which the drugs act, and we are trying to elucidate these structures by a systematic investigation either of the inhibitors of the drug action or, more directly, of the difference in the fine structure of active compounds and of related inactive analogues. One of the most elegant examples is that of acetylcholinesterase, its poisoning by organic phosphorus compounds, and its recovery by antidotes.

In this, a hydroxyl and a negatively charged group form part of the active site of the enzyme, and indeed, phosphorylated serine could be isolated from a hydrolysate of the inactivated enzyme. Another characteristic example is provided by the morphine series. One has developed a picture of the morphine molecule, which appears to be able to envelop a certain part of the chemoreceptor; this conclusion has been reached by a study of morphinelike active and inactive compounds. In the case of the drug methadone, e.g.



we have found that if one gives the activity of its racemic form an arbitrary value of 100, the dextrorotatory form has an activity of 10 and the levorotatory one (which has the same configuration as D-alanine) a value of 180.

As a result of such elaborate studies and by the use of antibiotics, we have been able almost to eliminate bacterial diseases; we remain faced with various metabolic disturbances and with viral diseases. They will be the target of research in the future. It is gratifying that some antibiotics have recently been discovered that are antiviral agents, but, more important, some deeper insight has been gained into the biochemistry of viral action, of which we know much

less than that of bacteria: it has, for example, been shown that the cancer-producing viruses require arginine for their reproduction.

Two other medicinal areas that will be of increasing importance are those of psychopharmacological drugs and contraceptives. Both areas are in a state of active development, both are undergoing some regression because of side effects that surely should have been expected. However, there is no doubt that the development of such compounds will continue, the former not only because of the necessity to find cures for mental diseases but also to neutralize the deviations from the optimum use of our mental and psychological facilities that the present structure of society entails. If we knew more about the mode of action of the psychopharmacological drugs, it would be easier to educate the public and to prevent the present abuses. As to population control, this is the second aspect of the rapid growth of the population of the globe, the first being, as pointed out already, an increase in food production. In both cases, it is interesting to note that we are returning to the habits of primitive people. Hallucinogenic drugs have been used since time immemorial in religious rites, and we are told that morphine had been known and used in the Stone Age. Fertility control was not carried out in primitive society by contraceptives but rather by abortifacient plant products, and it seems not unreasonable to predict that we will give greater preference to this aspect of population control, perhaps because we instinctively believe more in natural products than in synthetic ones.

Bulk Synthetics. In this field, too, the main progress made and expected to be made is based on a better knowledge of the relationship between the atomic and molecular structure of the compounds and their physical and chemical properties. We are approaching the time when we can speak of "tailor-made" molecules. This is true for metals and metal alloys used in magnetic devices and electronic components, and also for organic synthetic materials, although our knowledge in this particular field is semiempirical. We are concerned with disordered or partly ordered aggregates of molecules, an extreme case being glass, a field in which impressive progress has been made in recent years. In the field of plastics and rubber, the knowledge based on our experience is great, but it will have to be deepened and enlarged. We know about plastics that are resistant to high temperatures, about polymers that have a low viscosity index (temperature dependence of viscosity), about plastic materials of high mechanical strength. However, as already pointed out, we will have to proceed in the direction of structural materials of synthetic origin to replace the metals now in use.

The art of organic chemistry can produce molecules of quite unexpected properties, such as organic semiconductors, photoconducting substances, or compounds that can serve as the "memory" of computers. The great variability of organic structures makes the production of materials with desirable, specific, and well-defined properties a matter of time rather than of principle.

It would not be wise to conclude without noting the field of military chemistry, not only that of propellants, which for obvious reasons will continue to be developed, but also that of chemical warfare agents. It can be hoped that we will reach a point at which the danger from the use of such chemicals will cease to exist, but in the meantime it is obvious that we have to expect further development, especially of incapacitating agents that will probably belong to the group of psychopharmacologically active drugs. Another area

that will have to be developed further is that of protective agents against ionizing radiation and against gas warfare.

The foregoing is a wide panorama that, of course, has much to do with practical problems with which humanity is faced or will be faced in the future. Nevertheless, it should be obvious that in order to reach these goals, a great deal of basic research is necessary. In fact, it seems to me that the dichotomy of which so much is being made today is an imaginary one. Basic understanding is necessary if we want to design applied-research projects and carry them into effect. Scientists and planners alike will have to show great wisdom in apportioning manpower and funds to these two avenues of scientific and technological development; very often the best approach to the solution of problems of great urgency is the fundamental, the long-term approach.

PRODUCTION AND DISPOSAL OF WASTES SOCIAL CONSEQUENCES—POLICY IMPLICATIONS

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Introduction

Every living thing, vegetable or animal, produces waste products, the emission of which is necessary for the continuation of life. Production of goods similarly is accompanied by the discarding of waste products because no process makes complete use of its raw materials. Developed industrial nations produce a surplus of goods that are exported to less efficient or less developed nations and accumulate the wastes resulting from such production. The surplus goods are exchanged for more raw materials, including much waste to be disposed of by the more productive nation. The natural result is for the more efficient producer to bury himself in his own waste.

These wastes alter the soil, the water, and the air that are necessary for human existence. With small population concentrations, a group of men could abandon the area of activity when the waste pile got too large and shift to another area for gathering food and carrying on their minor production of goods. With more concentrated populations and intense industrial production, capital investment in cities and factories deterred the abandonment of occupied areas, and pollution of air, water, and soil became a recognized problem.

As early as 1306, a royal proclamation was issued by Edward I against the use of sea coal, because it filled the air with pestilential odor. A century later, further regulations to control smoke and odor production came from Richard II and Henry V. In 1661, John Evelyn published his "Fumifugium—Inconvenience to the Aer and Smoke of London Dissipated." Evelyn was instrumental in the building of St. James Park and other open areas around London, planting trees and flowering shrubs to purify the air and counter the concentration of such industries as the slaughterhouses, tallow-rendering works, and brickyards to the south side of the Thames River. As these plants increased in size, the chimneys were carried higher to dissipate the smoke above London Town. Early experience and recent research show the failure of dispersion and dilution from taller chimneys.

Affluence and Waste

Man upsets nature's balance of production and deterioration and successive use of refuse as food. The unbridled expansion of production without use or storage of the waste products is suicide.

Affluence comes from overproduction of the necessities of life and is therefore directly responsible for waste and pollution. The size of the household garbage can is a measure of the affluence of a people and of the severity of pollution in the area occupied by that people.

Life generated by, and existing within, a set of natural conditions can tolerate change in the natural conditions by time-dependent acclimatization, such as living in an air-conditioned environment. But every such change requires the production of goods and of power, with an offshoot accumulation of wastes to pollute the air, the water, and the soil, and even the natural light and heat from the sun.

Except for the very few "nature children" or bush people in the center of Australia, no one wants a return to the good old days before electricity or even before steam. And to earn the benefits of the power added to the energy of man and to that of his domesticated beasts, of extensions in the provision of food, shelter, clothing, mobility, interchange in word and thought, we must pay the price of disposal and control of waste production. If the waste problem is not solved, we do not earn the benefits desired and obtained from any development in production.

Every living thing continuously produces wastes and contributes them to the air, the water, and the soil. Are they necessary replacements of food for other forms of life, or are they surplus waste and therefore pollutants? Each level of life produces wastes for the beneficial use of other, not necessarily lower, levels. How can the balanced ratio of production and use, in effect the elimination of affluence, be determined and controlled?

Source of Raw Materials

All raw materials for production of food and goods come from the earth's crust, from the waters that hold desirable compounds in solution or suspension, from the chemicals in the air, and from the waste products of vegetable and animal life. Waste products are disposed of in the soil, the water, and the air of the environment. All material gained from the removal of resources must be balanced by restoring the used-up volumes. As a slow but continuing geological agent, man depletes available resources and must find substitute products with the remaining sources of ever-scarcer materials and completely new designs. Many of these scars in the crust—abandoned worked-out mineral, fuel, salt mines, cavernous deep vacancies of oil and gas production, gullied surface coal mines, and even depleted natural water courses—become limitations to the farming and urban uses of the land. Continuous increase in population pressure, at least in direct proportion, intensifies such an imbalance in the natural state of the earth's crust. Replenishment of natural resources by recycling of waste and obsolescent products must become a normal way of life, or progress will be throttled.

Chemical fertilizers have largely replaced animal products for restoring the food-producing qualities of farm lands. Vine-covered arbors were seen along farm roads in China before 1940 as an inducement for the traveler to leave his animal wastes for use as fertilizer; they are not now considered a proper source of that raw material. To the native farmer in India, the cow is not a problem but a necessary link in the chain of the living cycle. Children as young as three, with flat baskets on their heads, follow the animals to collect the droppings. Flat cakes of dung are collected, dried, and stacked in front of their huts as the only source of fuel and fertilizer. The size of the dung pile is a measure of prosperity and also of family size. Eliminate the cows and you eliminate the life of the millions of peasants. When India can pro-

vide substitute fuel and fertilizer, producing new kinds of waste pollution, the economic necessity for large families will be reduced, and the control of population may make more sense to these people.

In many parts of the world, organizations of well-intentioned men have for many years preached the gospel of careful use of our natural resources, with some success in providing for future generations. Some, like the Sierra Club, are chiefly interested in keeping the earth habitable for those who live in it. They warn man to stop devastating forests and swamps, stop lining and diverting streams, stop the use of pesticides, eliminate air pollution and supersonic noise. Return life to early natural conditions—but how far back in the progress of mankind's technological development would the present generation be satisfied to go?

Wasteful Use of Resources

Older civilizations drifted into more efficient and less laborious production of food, clothing, and shelter, and without planning for the future were buried by their wastes. Can we control our destiny, or will the skyscraper be a mysterious symbol of our civilization in some future archeological explorations around present centers of population congestion?

In 1966, the U.S.A., with 6 percent of the world's population, consumed 34 percent of the produced energy, 29 percent of the steel, and 17 percent of the timber. And the lumber industry, in fear of competition from aluminum, steel, plastic, and other substitutes for their housing market, continually pressured the Government to allow larger timber removal.

In 1966, we also dropped 48 billion empty cans, many of them rust-proof, and 26 billion bottles. The production of 800 million pounds of trash each and every day is enough to cover the entire land area soon. Of one billion pounds of paper produced, one-third is reclaimed for new paper or other goods; except for the small amount consigned to library and commercial records, the rest is waste. Again in 1966, 9 million vehicles were discarded.

As to food use, the mark of our affluence is the large garbage can. This was expressed in 1948 at a reception in Rotterdam by the Deputy Burgomeister, who had been in the U.S.A. before the war, and who said: "Do you still have those large garbage cans?" Europe learned by necessity, during and for some years after the war, that food can be more efficiently used without detriment to production or health. However, by 1960 the lesson was forgotten and the old habits of wasteful food use have returned. The "haves" are only a small island of plenty in the entire world population of relative scarcity, poverty, and hunger. As national groups become developed, they tend to copy the wasteful use patterns of the minority.

In his December, 1862, message to Congress, President Abraham Lincoln included the biblical quotation: "One generation passeth away and another generation cometh, but the earth endureth forever." The basic laws of mass and energy restate that truth but do not stop the alteration of the natural resources, without replenishment, so that a generation can rob all future generations of their source of many necessary materials and of power. In 1952, President Truman's committee to "study the broader and longer-range aspects of the nation's materials problem as distinct from the immediate defense needs" issued the Paley Report in five volumes of valuable information.

Most important was the warning that in the 1940s the U.S.A. passed the point of no return, consuming more natural resources than could be produced from available sources. And of 72 strategic and critical materials listed by the U.S. Munitions Board, 40 had to be entirely imported and some of the others were partly imported. The wasteful use and lack of recycling of natural resources will be the deterrent to future progress.

Pollution Production

The available air, water, and soil are limited not only in total quantity but even more in usable volume. If their use is limited, natural cycling of change will not denude the available resources. If used without thought of the future, any material can be exhausted, even if present sources are plentiful. The disposal of wastes into natural sources not only diminishes their usable volume but also affects the availability of other resources. Annually, some 160 million tons of solid particles are emitted into the air from the U.S. and some 800 million tons around the world, loading the atmosphere with dust. The effect is not only degraded air but change in the normal trade winds, change in cloud formation, change in the daily and annual temperature cycle, and change in the rainfall pattern. Rainfall upwind and downwind of the Gary steel mills in Indiana varies by almost 50 percent.

Total precipitation per day is given by Gale Young, of the Oak Ridge National Laboratory, as $340{,}000 \times 10^6$ gallons, 21% on land, and by G. P. Kalinin and V. D. Bykov in the UNESCO report as 520,000 cubic kilometers per year—about 10% higher than Young's figure—with 21% on land. Of the rainfall on land, the only present usable source of water, two-thirds evaporates, leaving some $24{,}000 \times 10^6$ gallons/day (7% of the total rainfall) available for use. Much of this falls in unpopulated areas. Some water is from glacier melt. Even for a population 4×10^9, there is an available total of 6,000 gallons/day, or a hundred times present average requirements. All of the waters eventually go into the seas, and, unfortunately, they are not well distributed over the earth. The Amazon River supplies 20% of the total runoff, and the next 20 largest rivers—the Hudson River is the 21st—total only 19% of the runoff. The runoff of the Amazon into the sea exceeds the total U.S. rainfall.

The runoff, without help from man-made wastes, carries soil particles into the sea; evaporation does not return them to the earth, and there is a continuous loss of available land for food production.

Man's use of the land adds wastes and pollutants directly to the sea and to the waters that travel to the seas. In the U.S., water heavily polluted by household wastes totals 20×10^9 gallons/day, and industrial-waste water is twice that volume. Materials are disposed of in solution and in suspension and are not easily altered or absorbed by marine organisms. Farming adds herbicides and pesticides, 10 million boats contribute sewage and oil wastes, storm water from paved and covered land brings silt and salts used for snow removal, and a substantial amount of abnormal heat removal further denudes the dissolved oxygen of the receiving waters. By 1980, a sixth of the freshwater runoff in the U.S. will be needed for cooling in power-plant operation, with a possible doubling of that volume by the year 2000. The effect of such large thermal change is unknown but must be determined. For example, the

Milwaukee River, in an area of winter temperatures consistently below 0° F, does not freeze over.

The large volume of the oceans makes them appear to be a logical and safe disposal pit. But it does not work that way. Disposal by estuary and outfall into the oceans merely concentrates the fine residues along the shores. The trend of movement is shoreward rather than seaward. Ocean movements tend to concentrate the waste materials towards the shores rather than into the ocean deeps beyond the continental shelf.

In the period of industrial development, the cities occupied infertile hills surrounded by farmland; in this century, population concentration has caused the expansion of urban areas to cover and wipe out large farm developments. For example, most of the potato farm area in Long Island has been covered with suburban developments. The construction industry also encroaches on food production for supplies of its raw materials. Sand and gravel beds are being depleted at the rate of 6 percent per year (11 percent in the Mid-Atlantic section) in the U.S., leaving large denuded areas for rapid erosion. Some have been developed as artificial lakes for recreation and park use. Pits for ornamental granite in the islands of the Penobscot Bay in Maine were dug to such depths that stress release cracked the natural rock beds and abandoned scars were left, surrounded by huge piles of shattered and seamy rock fragments. These abandoned man-made geological changes in the earth's crust must be utilized as storage for sorted waste to become future mines for usable and necessary resources.

Accumulation of mine wastes in unstable piles has resulted in slides with serious consequences; one such was the loss of 200 lives when a conical pile of coal waste slipped into Aberfan, Wales, in 1966, engulfing an occupied schoolhouse and 18 homes.

Were it not for the rapidly increasing yield of farmlands, due to technological developments and improved seed, the available farmland would have become a critical control of human life on earth. There is not too much total land available, and there is none to be turned into wasteland. Of the 22.2×10^9 acres, 55 percent is arid. Main crops and grain cover 2.3×10^9 acres, with minor crops on about 50 percent more area. Pastureland used 6.4×10^9 acres (29 percent of total land), some of which could be upgraded for more intensive food production. The total irrigated farmland is 0.3×10^9 acres, and only serious famine and higher food prices would significantly increase the area. Of the arid regions, fully a third are located more than 500 miles from any source of water that can be processed for irrigation.

Energy production and energy release into the environment are becoming more significant pollutants with the rapid increase in power requirements. David A. Berkowitz, of the Mitre Corporation, estimates that the energy now released artificially by man equals 1/2,500 of the radiation balance on the entire earth's surface and the release is increasing at 4% per year. The environmental compatibility of power generation is associated with the heat balance of the earth as well as with pollution of air, water, and soil. The estimated power consumption in the U.S.A. for 1970 is 1.5×10^{12} kilowatts, with a 50% compounded increase for each decade. Solid, liquid, and gas fuels need expensive sulfur control for their combustion gases. An oil-desulfurization plant, with the capacity to produce 100,000 barrels of low sulfur fuel oil per day, costs $150 million.

Atomic energy plants have gas, liquid, and solid wastes. Gas wastes can be

precipitated and added to the solid waste. Solids are shipped to fuel processors, treated, and stored. The AEC estimates that by the year 2000 there will be 800,000 cubic feet of solid waste stored in 700 acres of abandoned salt mines. And some 200,000 gallons of tritium-bearing water is disposed into deep wells each year. The Hanford plutonium plant has 20 tanks, each containing 500,000 to a million gallons of stored liquid solution of waste products. Waste storage becomes a major item of the production program and may be the incentive for further development of solar energy to meet future demands.

Solution of the Problem—Use the Wastes

The solution of the problem is not elimination of technological production but better production controls, with major deletion of wastes by using them. Some 20 years ago, Swift's new hog-slaughter and packing house in Chicago advertised the complete use of the animal; everything but the grunt was packaged into salable items. But air and water were still polluted by the process. Air pollution from the power plant can be reduced by chemical and physical filtration of exhaust gases or, if the problem of atomic waste disposal can be solved, by the use of atomic energy. Water pollution can be reduced by liquid recirculation and reconstitution. Costs will be increased but protection of the environment for future generations is a small addition to the cost of raising and training each successive generation.

The technology for water pollution control is available; for air pollution control, it is still under study; for solid pollution control, it is just being analyzed. The solution of these problems is the most urgent task facing the present generation.

The return of large fractions of solid wastes to use in the economy must become common practice in every industry and must be a national objective for immediate implementation. There are now some 10 to 20 million discarded motor vehicles stacked in junkyards. In 1966, some 6 million cars were returned to the steel mills, but another 6 million were added to the junk pile. The process must be speeded up to clear away the 50-year accumulation of wastes. A system should be developed to collect, sort, transport, salvage, process, and recycle all worn-out materials. The system must be more efficient than that of the flea markets of many old countries, such as the one in Old Delhi, where continuous trading in trash, junk, and waste is in progress.

The Bureau of Mines has collected much valuable data on waste disposal and reuse. Included in their reports are case histories of reclaimed metals from magnesium foundry waste, aluminum dross, electrolytic recovery of zinc from sal skimmings, extraction from S-816 alloy scrap, cobalt-nickel from superalloy scrap, vanadium scrap, lead and copper from blast furnace matte, silver from waste photographic solutions, copper from auto scrap and from molten iron, aluminum and fluorine from leached potlining residues, titanium from residues, minerals from mica tailings, and gold from electrolytic solders. Automobile and refuse disposal has many recovery possibilities.

The Reynolds Aluminum Company, to reduce solid waste disposal and stretch the supply of natural resources, is active in the reclamation program. At present, 30 percent of its aluminum products use reclaimed or secondary material. In the last three years, Bethlehem Steel Company has spent $67 million, or 5.6 percent of its capital investment, in environmental control improvements in connection with their production.

Economic utilization of industrial wastes, scrap metal, mining wastes, and municipal refuse must be planned to produce usable products and recycled resources. Production costs may require subsidy, and such funds should come from a charge against the products or process that produced the wastes. In this way, solid wastes become a source of raw materials and can be converted into useful building materials, insulating fibers, mineral wool, mulches for agricultural application, and fertilizers. Ferrous and nonferrous metals must be recycled. The technology for such development is available. The concept of charges against the producer of the wastes is not novel; many jurisdictions make a charge for liquid-waste disposal as a percentage addition to water-supply charges. Some examples of waste utilization indicate economic solutions without subsidy. Above the Conowingo Dam, on the Susquehanna River, the accumulation of coal dust from the washing operations upstream is pumped as a slurry and injected into a furnace for steam operation and electricity production. The only cost of the fuel is the pumping cost; production is very economical. Arid soil at Phoenix developments becomes lush gardens when household garbage is buried therein. Sawdust accumulations at lumber mills make good bases for roadways that cross deep marshes. Glass fragments have recently proved good mineral fillers for asphalt-mix roadway surfaces.

Water salvage in industry is one method for reducing pollution of the streams. With an average precipitation of 170 gallons/square yard per year and a national average household use of 60 gallons/day per person (100 gallons in the Southwest), better water harvesting from rain catchment areas and reduction of seepage and evaporation losses should protect the necessary supply for many generations. Such plants as Kaiser Fontana Steel save, recover, and reclaim water for use; it uses 1,400 gallons per ton of steel produced, as against a 65,000 gallon average for the entire steel industry.

The estimated 1980 water requirements are: Industrial, 243×10^9 gallons/day, with 224 reusable; seepage losses, 760 with 25 possible saving; irrigation, 136 with 20 saving. Additional reductions in present uses in control of household supplies, and correction in conduit losses can further help to eliminate shortages.

Control of dust and fumes from industrial plants, buildings, and vehicles can be accomplished by expenditures that will increase the cost of production, climate control, and transportation. We dare not refuse to spend the extra price for protecting the atmosphere. Some industries have actively incorporated necessary protections. Asphalt-mix plants normally belch dust and fuel-oil smoke from their chimneys. Adding sonic water atomizers in the chimney removes 98 percent of the dust particles at 3-to-15-micron size and 80 percent of the particles smaller than 3 microns. Scrubbing water is atomized by a blast of steam or of compressed air, and a second blast of air produces high-sound energy to induce vibration in the droplets, providing beneficial microscopic turbulence and aiding in the surface collection of solid particles by the water droplets. The added cost to the finished product is minimal.

Conclusion

Production of wastes is a necessary condition of any life or of manufacture. Control of the wastes to reduce deleterious effects on the air, water, and soil that sustain life must be a recognized duty of each producer. Reuse of salvageable resources in refuse and cast-off goods must be planned and executed as a future source of raw materials. These are not public duties and should not be considered the province of government, but a planned step in the production of any item using natural resources.

* * *

VON FOERSTER: I would like to address myself explicitly to a problem to which I think many of our speakers in the past have addressed themselves implicitly—the problem of perceiving a problem in its totality and solving that problem in the context of that totality. In this formulation I would like to draw your attention to two terms: One is *perceive* and the other is *totality*. And I think the concept of environment is really an example *par excellence* for contemplating these two concepts.

Certainly, perception of the environment is as broad or as narrow as we perceive. The environment around us is quite clear, but it is only recently that we discovered we are surrounded by an environment. People say—Look, we are living in an environment, and the people look for a second and say—My God, we have an environmental crisis. But of course these are questions of perception.

I think it was very beautifully illustrated earlier by the gentleman from Geneva who pointed out that about 15 years ago probably nobody would have perceived that Lake Geneva would be dead today. And then he made the very interesting remark that perhaps a poet may have seen it coming 15 years ago. But the most fascinating thing, I believe, is if this poet would really have said it 15 years ago, nobody would have understood what he was talking about. We would not have listened. We would not have shared in his perception.

And in this context it has nothing to do with the eye, or the ear, it has something to do with the brain, the cognitive realization of what is going on. So much for perception.

Now I would like to point to totality with respect to environment. Environment is, of course, a labor of considering a totality, because whenever we leave something out of our contemplation of the environment, including the observer who observes the environment, then we are not addressing ourselves to the problem of environment but to certain aspects of this environment. For instance, we are talking about astronomy, geography, geology, chemistry, biology, et cetera, et cetera, et cetera. The tragic thing is that if we go further into the specializations, we get further and further removed from addressing ourselves to the problem of totality of environment. Then we are faced, of course, with the fantastic problem that, in order to consider the environment, we have to contemplate the twofold or trebleFold relationships of these actions between these individual disciplines.

This is called interdisciplinary studies, and the University of Illinois today offers approximately 140 different fields of studies. If you consider two of these studies to make an interdisciplinary topic, then you have about 10,000 such topics. If you consider three fields, we have about 144,000 of such interdisciplinary studies. Would anyone like to know what happens if you take four of these interdisciplines? It is approximately five million. If you have two majors and two minors—the beautiful thing is that every American student can take his particular individual study and there will be no second one who will take exactly the same.

In a way, it is a very nice solution, but I don't think this is the way to

approach totality. Therefore, what I propose to develop is a holistic calculus or the epistemology of the closed system or the epistemology of autonomy. It is extremely difficult, not because the topic is so tough, but because you slip again into the specific fields and might be seduced by the beautiful possibility of quantification. This works very well if we have a few tremendous successes. As you know, this is a temptation.

Consider physics, which is of course a success at picking two or three or four variables, not more than four variables; if you go to larger variables there is a diminishing return when you compare the formulation of the problem with what you call the formulation of the solution. Let me say something about what we consider a problem and what we consider a solution. Usually we conceive a particular situation, formulate it linguistically, and reduce it to a quantifiable formalism, and then there is a differential equation. Then we churn through the mathematics *vis-à-vis* the tautological transform, then you see an equal sign, an equal sign, an equal sign, et cetera. After you are through working with it through the transform, which is called integration, you have a solution. There is no change, of course, in the information that drew that information, which is not the problem, which is in the solution. If there is anything in it or anything lost, then you have made a mistake somewhere. Then you contemplate the solution. And in many cases we say we gain some insight when we transform tautologically the problem that is formulated and contemplated. Solution.

Indeed, some people have some difficulty in conceiving a differential equation, and they like to see the curves. A fascinating thing takes place; if you go to more and more variables, you may be able to write up the problem. Indeed, you can solve it. But if you are not looking at the solution, you are as confused as if you look at the problem, because the opacity of the solution is as great as the opacity of the problem.

The question is, how does one address oneself to this kind of problem? The proposal here is to really reconsider what do we do when we make these transformations. What we usually do is, we attempt to reach, by a transform or by a paraphrase, new insights into the relations of the objects of our studies. And indeed by this transformation we usually get new insights, and we are stimulated to look at the problem from a different angle, which is usually extremely hard to make with these transformations just in one's mind.

The question of diminishing returns comes about because the number of variables becomes so large and the solution is as opaque as the problem. Then the question arises of whether one cannot just make a short cut, never going through the mathematic transformation but making the computation in the semantic domain, which means computing, within the semantic structure of the problem, paraphrases that will provide us with similar kinds of new insights by the new formulation of the problem obtained through semantic transform.

I have a couple of fascinating examples that we have gone through with some of our semantic computing programs, and I would like to give you one. I would like to speak about a rather simple problem which is perhaps very close to our hearts, the formulations of the growth of populations. I will not go through any mathematics; I will give you paraphrases of one and the same type of problem. The interesting thing is that these paraphrases are really nothing else but tautological transforms. But if you listen to these paraphrases, you will find that you think or believe or feel you have a new point of looking

at that structure. I am talking about a growing population, and I will read a couple of these paraphrases.

One: The increase of elements in the population per unit time is proportional to the number of elements at each instant. Wonderful! Same thing, transformed; the relative growth of the population is constant. Exactly the same form. Two: The size of the population at any instant is proportional to its size at an early instant which precedes the former by a constant amount of time. Three: The population growth is exponential with time. Four: Formation of the doubling time of the population is constant.

You look at Utterance Four and you know, of course, that, if applied to the population, it is false; therefore can you wipe out all the other ones in the human population? It is great that the relative growth is constant, but you wipe it all out because the last one is false. If we contemplate the human population, we know of course that the doubling time is linearly decreasing with time. Good. Let us plug that into our semantic computer and we get the following formulation: the doubling time of the population is a linearly decreasing function of time. Paraphrase: The population is unstable.

I would like to leave it at that and point out that this might sound almost like one of those enigmatic prophesies of a poet. And perhaps it will suggest to you the difficulty of seeing and perceiving a totality. And in particular with this point, I would like to draw your attention to a short statement by Margaret Mead in a paper she is presenting to this Conference. She says, "Essentially there is no observation of any kind of behavior or record of behavior from the shape of the human jawbone, the contour of a hand, or the form of a gesture or the way of holding a knife or a pen that cannot be fitted into this figure of a whole." And I think we have to follow this vision and contemplate a whole. Thank you very much.

CANCRO: This paper was written to serve as a supplement, a discussion, an amplification of a paper that was to be presented today but was not. It must, therefore, stand on its own and is perhaps a bit more naked than I would have ideally wished. [Dr. Cancro's complete paper is published elsewhere in this monograph.]

We were told earlier here that it is a peculiarly American trait to desire simple answers to complex questions. This statement can be safely generalized to the rest of the species. The simple answer is seductively attractive, for it can be quickly grasped, firmly held, and readily applied. The scholar is not above this temptation, since, as you recall the concept of parsimony in science —as exemplified in Occam's Razor—favors the more simple explanation. The possession of answers reduces anxiety, but it serves best when you understand the explanation. Therefore, we all seek, to varying degrees, the simple solution.

Computers are in danger of becoming a simple solution to the problems of the environment and society in the minds of some. It is true that the new large machines can perform incredible computational feats, but this is a far cry from generating the solutions that we must produce for ourselves. Electronic computation is a powerful tool whose potential application to societal and environmental problems is real but undemonstrated. Computers have demonstrably altered and will continue to alter society at an accelerated pace in a variety of ways, not all of which are desirable or even foreseeable. Man's adaptive efforts, both biologic and psychologic, will be profoundly affected by the environmental consequences of computer-based technology.

Perhaps the most important mental operations that man performs are those

that mediate his psychological adaptation to the environment. Adequate individual psychological adaptation is an essential prerequisite for species maintenance. It requires the establishment of a viable, dynamic equilibrium between the demands of an individual's internal and external worlds.

In most higher biological species, adaptation relies partially on social organization. In man, these social institutions are transmitted through the medium of culture. An individual, therefore, must adapt not only to the physical and interpersonal environments in which he finds himself, but to the existing social institutions as well. Any radical alteration of the environment, including its social organization, necessitates a change in the dynamic equilibrium between the total environment and that individual.

These theoretical formulations suggest the value of studying and beginning to model the predictable effects of programmed machines on both social institutions and the physical environment in order to anticipate some of the likely consequences on man's efforts to adapt psychologically. One such institution that will be radically altered is work. There are, of course, a number of qualitative and quantitative changes in the nature of work that will be produced by automation.

I would like to summarize a schematic model of highly probable direct and secondary consequences in an *unplanned* economy, and the likely direction of their relationship. Theoretically one can assign values that express the strength of certain of these relationships and thereby produce a variety of numerical results. The present state of our knowledge concerning the measurement of the social variables in question, let alone their interrelations, is so meager that such an assignment of values, while feasible, may be premature.

However, a simple qualitative examination of the schema can be productive. This technique of pyramidal schematization need not be restricted to work but can be used to model conceptually the effects of programmed machines on a variety of social institutions that impinge on man's psychological adaptation, thereby ultimately creating a large, complex, interacting model that may adequately simulate the real system.

Programmed machines are of central importance in the automation of a variety of production processes. The automation of these production processes will, in turn, increase the level of both national and individual productivity. This increase in national productivity will contribute to a variety of pollution problems through an increase in the utilization of energy sources. The increase in individual productivity will also result in an increase in purchasing power for the individual worker. This increase in purchasing power also raises the danger of further pollution of the physical environment, because it may result in even more conspicuous consumption, for example, more cars, boats, snowmobiles, etc.

Another highly probable, or first-level, consequence of automation is a diminution in the length of the work week and a resulting increase in the amount of available leisure time. The immediate consequence of this change would be a reduction in the amount of time spent in relatively structured work activities and an increase in the amount of time spent in relatively unstructured leisure and family activities.

Man's psychological adjustment is affected in highly individual and variable ways by the amount of structured activity in his day. In addition, any sharp reduction in the number of hours worked weekly or in the total length of the work life must be accompanied by a diminution in work-related sources

of satisfaction and work-related opportunities for the acceptable discharge of otherwise socially unacceptable drives.

Clearly, there would be a complementary increase in the amount of time for leisure-related satisfactions and leisure-related drive discharges. Unfortunately, Western man has more experience with the use of work as an adaptive device than he does in the use of leisure time. In our technologically advanced, Judeo-Christian society, there are very few people who know how to use leisure time productively. Enforced early retirement is usually a euphemism for imminent death. On the other hand, the increased purchasing power available to people may make it economically possible for them to utilize this leisure time in ways that support adaptation.

There will be a number of individuals who are unemployable simply because the range of skills necessary for the operation of a highly automated society is diminished. This raises a potential problem of the creation of a technological aristocracy on the one hand and a technological peasantry on the other. It is a hollow liberation from work for a man who lives in a society that says, "you have a right to consume what you produce." The reduction in the total number of jobs per 100,000 population increases the probability of a variety of devices being utilized to defer young people's entry into the work force. In recent years, these have included prolonged education, the draft, and discrimination.

As racial and sexual discrimination diminish and the draft is curtailed, there will be an even larger disproportion between the number of people seeking work and the number of available jobs. If education is not to be a transparent device for frustrating young people's legitimate desire to enter society as full and productive members, it may have to be radically altered, made interruptible, and perhaps even shortened for many.

Automation will continue the trend established by industrialization to reduce the physical effort expended by the worker on the job. There is a relationship—the exact nature and strength of which is unclear—between physical effort and mental health. In order to maintain good psychological adaptation, man needs to use his muscular system.

Manual labor has also been a traditional source of masculine pride and self-confidence for many. There is clinical evidence to suggest that men who are underemployed often compensate for it by refusing to practice birth control and fathering large numbers of children as the visible evidence of their manliness. The danger of an increase in population as a result of a loss of traditional sources of support for masculine identity for certain groups must be considered.

The trend toward less physical work in combination with prepackaged leisure-time activities—for example, television—can combine to produce an increasing homogeneity of perceptual inputs as to both variety and intensity. That this alteration of perceptual pattern input may play an important role in mental adjustment is suggested by sensory-deprivation studies.

The increasing urbanization secondary to industrialization, with its resulting population-density problems, is also a critical consideration. The diminished need to concentrate population geographically in an automated society, along with the reduced work force and diminished working hours, may make it possible for the first time since the industrial revolution to achieve a more rational distribution of population over available land.

It should be clear that the above-stated relationships and consequences are

not inevitable but only highly probable in an unplanned economy. The goal of modeling this system is to increase society's ability to create rational options with known costs and benefits. The critical feature of this approach is the emphasis on the quality of mental functioning, and in that sense it represents an attempt to introduce traditional humanistic concerns into our scientific deliberations. It is not enough to provide for man's continuance as a biological species. We must insure the preservation of those distinctively human qualities that we value.

PERRIN: Next, Dr. Herman H. Goldstine.

SOCIAL IMPLICATIONS OF THE COMPUTER

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It is clear by now that the modern electronic computer is going to effect a change of profound proportions in our society; it will alter not only how we work and live but also how we think. This revolution is already well under way. It is, therefore, not wholly premature for us to spend some time and effort trying to arrive at a highly tentative, first orientation into some aspects of the scientific developments, social consequences, and, perhaps, even policy implications of these changes in our society.

To do this, perhaps we ought to ask ourselves a few questions about the foreseeable capabilities of the computer: Is it likely that machines will ever be capable of displacing man *qua* man from his tasks? To try to answer this question we should realize that man has always worked steadily to perfect tools of various sorts to improve his own capabilities. The greatest of these improvements, or at least changes, occurred with the perfection of the steam engine and its employment as a source of controlled power.

It is not our place here to trace the changes that took place in society as a result of this great invention; we can briefly summarize them by saying that it started the enormously complex chain of events that historians and social philosophers named the industrial revolution. Social historians such as G. M. Trevelyan have written admirable accounts of some of the changes that occurred in the immediate wake of that revolution, and it would carry us too far afield to try to recapitulate even a few of them. Instead, we may summarize in a sentence by observing that this revolution, viewed as a constructive force, freed man from labor that was often of an inhuman sort and afforded him greater opportunities to indulge in intellectual and recreational pursuits.

As far back as the 1670s, Gottfried Leibniz was saying: "It is unworthy of excellent men to lose hours like slaves in the labor of calculation that could safely be relegated to anyone else if machines were used." In 1876 Lord Kelvin said: "The object of this machine is to substitute brass for brain in the great mechanical labour of calculating. . . ." We can cite numerous other quotations of great men who realized how calculating machines could obviate the need for certain types of subhuman labor. In fact, virtually all technology and engineering is motivated by the understanding of the desirability of easing man's physical burdens, of improving his health, and of giving him greater freedom and mobility in his environment.

One of the greatest inventions since the steam engine—I feel it is the greatest—has been the modern electronic computer. It has enabled man to control information just as the engine enabled him to control power. At first this invention was put primarily to the solution of a variety of highly complex physical and engineering problems. But gradually the realization arose that not only the physical sciences and engineering were capable of making fundamental use of the computer but also all the other sciences, and humanities, the professions, and business. It was this enlargement of the role of the computer that ushered in the present era, with its potentialities and problems.

As far back as 1963, Representative Pucinski of Illinois had conducted hearings on the possibilities of a national information-retrieval system and a national data center. Since then there has been a steady increase in the technology available and in the progress made in using the computer in ever-wider fields of social consequences. In particular, people have become, by 1960 standards, very sophisticated in their ability to work interactively and remotely with machines, which have themselves become more useful because they can now present their results in various ways, including geometric displays.

I do not have the space here nor, probably, the expertise to discuss in depth the topic of the data bank as a social problem. However, it is desirable to say a few words on the subject and to refer the reader to the very important work on this subject by Prof. Alan Westin of Columbia University for a really penetrating study of the legal problems.

Probably there is not one of us at this time who is not acutely aware of the computerized data centers operated by the Internal Revenue Service and of the airlines reservations systems. These do not, of course, represent something unheard of. Indeed, all our efforts in science and the arts have been to categorize and store information, in tables, journals, books, filing cabinets, and libraries. This effort is central to our way of thinking and, at least since the time of Aristotle, has characterized our mode of thought. Thus, we can not thrust aside the increased desire to computerize the storage and retrieval of data. We must recognize it as merely a deeper and more profound extension of our past tendencies. I do not, of course, minimize the social implications of this happening, but we must realize that all improvements resulting from these consequences must be understood and provided for in our *corpus juris*.

While I do not pretend to understand how to cure the ills of our society, it is becoming increasingly clear that piecemeal treatment of large-scale problems is not useful or, at least, is not enough. Although this seems axiomatic, one can adduce the examples of weather prediction or modifications, or air and water pollution control to realize that problems of this sort must be handled on a scale commensurate with the natural boundaries of the problem: thus, to predict the weather here today we need to know about the air movements, etc., for the last week in our entire hemisphere, and to discuss the pollution of the Hudson River we must look at its entire extent, including its tributaries.

You may take issue with my examples and say: These are all right, but how about masses of data about each of us in a central source? Here the potential dangers come sharply into focus, thanks to writers of all political shades. They have concentrated on the potential evils of a single, all-encompassing center having in its vitals a complete dossier on each person's financial, medical, criminal, etc., status. They have articulated how evil it would be for some unscrupulous person to have access to one or more of these dossiers.

Westin and others have considered the problems that national data centers will bring into our society, and I believe they conclude that there is a need for a continuing reshaping of our laws on privacy and due process but that we are not threatened by a national catastrophe. Indeed, in some respects the entire social system of our nation depends on large data banks. Without them, I do not see how we can properly collect the taxes needed to run our country and to maintain an efficient Social Security system or Veterans Administration program—to mention just a few of the most obvious ones.

In fact, the invasion of privacy by government is an age-old one. We need only look at William the Conqueror's Domesday Book to see an early example

of a data bank—albeit manually compiled and used—intended and used to enable William's government to establish a valid tax base. Chimney taxes and window taxes are two other trivial examples from which we may conclude that government is always encroaching on individual's privacy and that laws exist in part to ensure that the legitimate needs of government do not hurt the individual. As times change, so must the legal remedies and redresses open to the individual.

What is the alternative? To ban technological advance; to stand like King Canute and forbid the waves to advance. This is the Luddite view. It is, of course, impossible. Our only possible position is a dual one: first, work at our utmost to achieve applications and usages for nationalized or centralized information systems that will bring real help to our society, and second, to ensure privacy for the individual and security for the information about him.

Our society has made remarkable advances in physical and biological science and technology in the quarter century since World War II. With these great advances has come a considerable upset in our entire social structure. We may well ask why it is that a society so well adapted to science and engineering should be so ill-conditioned on the social side. Perhaps we should say a few words on this subject. Our successes have arisen in large measure from an understanding of how to assemble fairly large groups of technically trained people into coherent bodies, to fund them adequately, and to give them the freedom to follow the scientific trails they feel to be the right ones. All this sounds easy, and, even worse, trite, but in fact these things were learned only within our lifetimes. In any case, this particularly fruitful technique for invention has not yet been applied to the understanding and correction of our social ills. Very likely this will happen in the relatively near future and will make fundamental use of the computer in two ways: as a device for storing the vast amounts of data that will probably be needed to gain proper understanding of complex social phenomena and for simulating the result of various corrective actions. We have already discussed at least briefly the former point, but the latter one also deserves mention. The astronomer cannot perform experiments, but he can make observations, and he is therefore constantly on the *lookout* for bigger and more powerful instruments and newer observational techniques, such as radio telescopes, so that he can obtain a statistically significant sample of occurrences of a given phenomenon. The physicist, on the other hand, can usually perform experiments at will and therefore at will obtain a sample. The social scientist or social engineer is, unhappily, not quite in either situation. Very seldom does a given phenomenon exactly repeat itself, newer instruments will not help him to observe more occurrences, and he cannot will repetitions of a phenomenon and probably would not want to, since such events affect many people.

Therefore, he has recourse to the computer as a tool to simulate social situations. Once he has modeled the situation, in principle he can perform all the experiments he wishes and study the outcomes. Such a socially useful study was done in a large city where all ambulances were garaged in the municipal hospitals. The question asked and answered by the simulation was whether a significant improvement could be effected in providing service to the public by establishing a satellite garage away from each such hospital and what was the optimal location for each satellite, if they were indeed desired. This study was concluded with considerable success; the desirability of satellites and their location were determined by a careful and thoughtful simulation.

Thus, in this quite simple situation, it was possible to perform a social engineering experiment without disturbing the environment and to find out practically how to effect a social good. One can, of course, give other examples, but I believe this one typifies one class of use for the computer.

The problem of the computer in our modern society does not turn on data banks alone. Indeed, the computer's most important impact on society may lie elsewhere. I am certain it will be of critical importance in the schools: universities, colleges, high schools, and elementary grades. I am not now talking about what is sometimes called computer-aided instruction but rather about the use of the computer as a tool to solve problems with great rapidity. As we are all aware, the computer is now becoming an indispensible tool not only of the researcher btu also of the teacher and his students.

To illustrate: in the sixth grade in the school in my little suburb, the children in mathematics classes are now learning, with the help of communication terminals, about mathematical concepts in most ingenious and instructive ways. In first-class universities and colleges the students in many courses are now being given homework to be done on computers. What is the consequence of this? The student previously had to do small, usually artifically simple, problems. Now he can cope with real or near-real problems of very large proportions. Moreover, he accepts the computer as a tool as much a part of his intellectual apparatus as the library. This is indeed a revolution. He now comes out of college trained to an intellectual level far exceeding that of his prewar colleague. He is much more sophisticated, more highly trained, and more useful to society. The implications of this change are awesome to me.

Finally, it is worth spending a little time to try to get some feeling for how intelligent "a machine can be." Much has been and will continue to be written on this subject. Here we have only space to say a few words on the matter.

In order to make headway with the problem, we find it convenient to distinguish between deductive and inductive reasoning. The former may be thought of as equivalent to the type often called syllogistic—we reason from "a implies b," and "b implies c," to "a implies c." The latter is more closely related to flights of intellect in which one reaches a conclusion, not by syllogistic reasoning, but by noting a number of cases and inferring a general rule or principle from them. This is perhaps the great faculty of the human mind at its highest moments.

Can the computer perform these forms of reasoning? As you perhaps know, some successes have been achieved in a few areas entailing fairly complex deductive reasoning. One interesting example is a geometry-proving program, written by H. Gelernter, that enables a computer to prove theorems in euclidean geometry with about the same facility as the typical high-school student in such a course. Although it is not exactly relevant at this point, this program gave a novel proof for a very elementary theorem: a triangle ABC with the equal angles $\angle$ ABC, and $\angle$ ACB has sides AB and AC equal. Usually this is proved by dropping a perpendicular from A onto BC at a point D and then by showing that triangles ABD and ACD are congruent. Instead, the computer showed that triangles ABC and ACB are congruent, i.e., ABC is congruent to itself and hence corresponding sides are equal.

Another and perhaps better example is a program written by D. Prawitz that proves theorems in the first-order predicate calculus rather better than most graduate students. This program is a nice example of deduction, and we must therefore conclude that computers can do this form of reasoning, although

it takes a very great deal of work to write such programs and there does not seem to be any particular transferability of knowledge from one program to another. This makes it difficult to see a great proliferation of programs in the near future.

The problem of inductive reasoning is more complex for human beings and, therefore, also for machines. One of the earliest and perhaps most interesting examples of a programmed device that learns general principles by considering special cases is, in my opinion, F. Rosenblatt's Perceptron. This is a machine that sees, via photocells, a simple pattern, such as an alphabetic character of varied shapes and sizes, and is rewarded in a certain way if it correctly recognizes the character and is punished if it fails to do so. The reward consists of an electrical means for enhancing the likelihood that it will again recognize the character.

It has been shown by A. Konheim that the task performed by the Perceptron is equivalent to solving a system of linear equations. In spite of this, the process as carried out by a Perceptron seems inductive in character. Other examples are furnished by A. Samuel's checkers- and G. Greenblatt's chess-playing programs. These are nontrivial examples of machines that can perform human tasks very well. In the case of Samuel's game, the machine actually learns how to play at least part of the game better by playing a number of games. It can, in fact, play championship checkers.

Thus, we have to credit the programmed machines with nontrivial abilities in comparison with human beings and cannot brush them aside as "being no smarter than the man who programs them." Indeed, even in solving strictly mathematical problems, there is a sense in which they do incredibly well. They can do what a human being cannot: they can carry out all the steps and make possible such feats as lunar landings and returns to home.

Let us now summarize: We have attempted to indicate the profundity of the changes that machines are effecting in our society; these changes are probably just starting and will become more and more pervasive with time. The computer as such is a really quite capable device but is, like all man's artifacts, a passive one until put to work. It will both create great changes in our society and assist man in solving his societal problems if is it used properly. The main problem, in my opinion, is to mobilize the public and the government to seek solutions to our problems in a clear-cut fashion. This probably means the creation of some sort of social engineering discipline in the great universities and, coupled with this, a very high-level governmental agency dedicated solely to applying the results of this discipline to the country's social problems on a broad basis.

Such a solution is not easy, nor can it be achieved quickly, but it is an essential one for us all. The computer has enormous potentialities, but the integration of it into our society may necessitate both university and governmental action.

THE CHEMICAL SCIENCES

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Introduction

Today, the general public is well aware of the significance and contribution of science and technology to life. Applications of new knowledge discovered in basic science have been dramatic and far-reaching. Progress in specific areas of technology has accelerated at an unexpected rate. It can truly be said that we live in an era of exploding scientific knowledge. Yet we still find the general public fearing ill use and wrong application of this knowledge—knowledge that it cannot comprehend.

The first part of this discussion will describe the origin and developments of the chemical sciences that relate to the problems mentioned in the second section. Consequently, this first part describes some facts of chemical science. I will then discuss the justification and value of chemical science in relevant areas of our environment and society.

Part I is based largely on the following two works: *A Short History of Chemistry*, I. Asimov, Doubleday & Company, Inc.,, Garden City, N.Y., 1965, and *Chemistry Creates a New World*, B. Jaffe, Pyramid Publications, Inc., New York, N.Y., 1962.

Part I: Origin and Development of the Chemical Sciences

The Ancients and Alchemy

According to anthropology, man is the only animal that uses tools. In the Stone Age, before 8000 B.C., man began to use stones and rocks as missiles and learned to shape them to give a cutting edge or a gripping end. The nature of substances did change: lightning might set fire to a forest and the charred wood or powdery ash was nothing like the wood that had existed before. Meat might decay and smell bad. Such changes in the nature of substances form the subject matter of the science we now call chemistry. Fundamental alteration in the nature and structure of a substance is a chemical change.

When man had mastered the art of starting and maintaining a fire, he became a practicing chemist, for he had to devise ways to combine wood or other combustible materials with air at a rate fast enough to produce sensible heat and light as well as ashes, smoke, and vapors. The heat produced by fire could be used to bring about further chemical changes; food was cooked and its color, texture, and taste were altered.

Mankind began to learn to make use of comparatively rare materials—metals. Copper was found in about 3200 B.C. In the Bronze Age, the Dorians,

a barbarian Greek tribe, used iron weapons to invade the Greek peninsula from the north in about 1100 B.C. They gradually overcame the more civilized, but only bronze-armed, Mycenaean Greek philosophers (about 300–600 B.C.), such as Thales of Miletus, Anaximenes, Heraclitus, Aristotle, Democritus, Epicurus, and others who had themselves developed the concepts of elements and atoms.

The era of alchemy lasted from about 300 B.C. to 1500 A.D. During the 17th century alchemy dwindled steadily in importance and in the 18th century became what we would today call chemistry.

Transition: Gases, Atoms, and Molecules

Despite its advance, chemical knowledge in certain respects lagged behind other branches of science. In astronomy, the importance of quantitative measurements had been understood since ancient times. The application was dramatized by Galileo Galilei (1564–1642), who, in the 1590s, studied the behavior of falling bodies. The results of his work led, nearly a century later, to the important conclusions of the English scientist Isaac Newton (1642–1727). But while Newton was building the modern structure of astronomy and physics with a beauty and solidity that amazed the scientific world, he remained immersed in alchemy. This persistence in the wrong approach was not entirely the fault of chemists. If they were slow to adopt the quantitative mathematical techniques of Galileo and Newton, it was because the material they dealt with was more difficult to represent in a fashion simple enough to be amenable to mathematical treatment. The work on *gas sylvestre* ("gas from wood") by the Flemish physician Jan Baptista Van Helmont (1577–1644) and Boyle's laws (Robert Boyle 1627–1691), were the first studies on gases. It was this simplest form of matter that first lent itself to the techniques of careful measurement; its science was a highway to the world of modern chemistry.

A French chemist, Antoine Laurent Lavoisier (1743–1794) recognized the importance of accurate measurement. This concept of "the law of conservation of mass" was the very cornerstone of 19th century chemistry. Lavoisier's achievements through the use of measurement were so great that chemists accepted the principle of measurement wholeheartedly from this time on. Lavoisier is universally remembered today as "the father of modern chemistry." Proust's Law, Dalton's Theory, and Avogadro's Hypothesis (1811) led the Swedish chemist Jons Jakob Berzelius, the Belgian chemist Jean Servais Stas (1813–1891), and the American chemist Theodore William Richards (1868–1928) to carefully determine atomic weights. Dalton and Berzelius adopted "symbols" in chemistry, and the usage of chemical formulas and equations became common.

In electrolysis, Faraday's laws seemed to indicate, in the view of some chemists, that electricity could be subdivided into fixed, minimum units, as matter itself could. In other words, there were "atoms of electricity."

Developments in the Chemical Sciences

During the establishment of the three major divisions of chemistry—physical, inorganic, and organic—many chemists were driven into interdisciplinary

areas of science. Thus, many further divisions of chemistry were created: biochemistry, chemical engineering, physical organic, physical inorganic, organometallic, nuclear chemistry, polymer chemistry, medicinal chemistry, bioorganic chemistry, bioinorganic chemistry, photochemistry, solid-state chemistry, electrochemistry, agricultural chemistry, analytical chemistry, neurochemistry, and many others. The giant area of science which includes the three basic divisions of chemistry and the other interdisciplinary branches mentioned above are called the "chemical sciences."

I have spent a substantial length of time describing the historical development of the chemical sciences because such essential knowledge—that of basic science—has often been neglected in justifying the value of the "chemical sciences" relative to our "environmental problems." Exhaustive listing of the major developments in the chemical sciences is impossible in such a limited space. In this section we will examine only a few of the major recent developments which are relevant to this article.

In the early stages of development of the chemical sciences, immeasurable contribution was made to human welfare by the isolation and synthesis of useful compounds and by solving problems of nature. Men were intrigued by the contributions of the chemical sciences. Chemists were proud of their achievements, and many enjoyed dedicated lives, spending most of their time in laboratories.

As time passed, chemists learned that poisons could be converted to useful compounds. Arsenic, though a deadly poison, was used in insecticides and to improve resistance to insects and shellfish of coating materials. But it was soon learned that, while the contributions of chemistry greatly improved men's lives, they also caused unexpected ill effects. The discovery of nitroglycerin, which led to dynamite, was a step toward improving man's life through better cultivation of land. But it has also shown great potential for harm in weapons. So let us also discuss the adverse effects of developments in the chemical sciences.

Food—Discoveries of new chemical fertilizers, insecticides, herbicides, and food additives have contributed to improving our food in quality and in quantity. But these additives also present the danger of excessive accumulation in human beings and useful animals.

Health Care—The contributions of the chemical sciences in this category have been so great that men may well have been spoiled by overreliance on such medicines as antibiotics, barbiturates, and assorted other pills for every occasion. Soap, detergents, bactericides, and other chemicals have improved sanitation. But it is these same detergents that are a major cause of water pollution.

Living Conditions—The race to produce new synthetic fibers has produced nylon, rayon, Orlon, and Dacron. Much silk and a large amount of cotton has been improved by chemical treatment. Chemically treated woods; better alloys, concrete, paints, and insulation; synthetic tiles; and many other materials have contributed to improving the construction of houses and buildings. Plastics are also changing concepts in construction. Further discoveries of such oil additives as tetraethyl lead—an antiknock agent—and new methods for processing petroleum have greatly improved the quality of liquid fuel for automobiles and airplanes. And, as in housing and clothing, natural materials treated chemically and synthetic materials have both made tremendous contributions to the construction of modern vehicles. But tetraethyl lead leaves intolerable traces of lead in the air. Synthetic fabrics are often flammable. Plastic, because of its low cost, is often used where a sturdier material would be better.

Population—Men have greatly appreciated the contributions of the chemical sciences mentioned above. But the more man's lot was improved, the more the population grew. If we cannot learn to control our own population, the abundance we have created will turn out to be a mixed blessing. And for solutions to this problem, man has again turned to chemistry.

Biochemical Aspects—Certainly among the most exciting work done in the last 20 centuries is that on the genetic code! And now a peptide has been isolated that seems to act as a memory carrier in rats. But consider also the possibility of the chemical creation or alteration of human life, the possibility of the chemical alteration of our very memories. Many people see less of the drama of this work and more of an incipient Brave New World.

Space Exploration—The moon landing recently made by the United States was one of the most outstanding achievements in our history. The success of this venture was due to advanced technology—with the chemical sciences playing a major role. But even here, who knows what Pandora's box of pestilence future space explorations may open? It is clear that, short of returning to a new dark age of stagnation, we must continue forward. But one cannot blame the citizen for feeling somewhat uneasy.

The trend is clear. Every improvement in human life has had at least the potential for harmful side effects. So let us bear in mind what has been done about the negative side effects of past technological innovations. We have: (1) Learned to live with the problem, (2) done away with those technological processes that caused the crisis, (3) used the technology that created the problems to solve them.

Part II: Chemical Sciences—Social Consequences and Policy Implications

Development and expansion of knowledge of the sciences has contributed immeasurably to the quality of man's life. But these contributions have often turned to negative influences that did more harm than good. Air pollution from factory wastes is now a serious problem. Our once-clean environment has been damaged—largely due to the efforts of scientists to improve man's life. That most fantastic discovery of modern alchemy, the preparation of new elements, was certainly exciting; but another application of this knowledge led to the creation of the atomic bomb. The chemical sciences prepared poison gases to kill insects, but chemistry was also able to make poison gases as munitions. The discovery of the genetic code and the possibility of elucidating the biochemistry of memory are amazing. Yet isn't the possibility of meddling with human heredity one of the most frightening of all those opened by science?

Man faces so many possible problems that a number of the more likely ones can be put in chart form. Shown here are some probable future problems and crises by estimated time and intensity.[*]

It is clear that among the general public there is a fear of the development of new scientific knowledge. We no longer have a situation in which science can do no wrong. If this continues—if the general public decides it will not support science—then science, for all practical purposes, will die out.

At present, scientists are urged to participate in solving social problems, such as air and water pollution. Many scientists believe that the urban and en-

[*] Plat, J. 1969. Science 1115.

TABLE 1

CLASSIFICATION OF PROBLEMS AND CRISES BY ESTIMATED TIME AND INTENSITY (UNITED STATES)

Grade	Estimated Crisis Intensity (Number Affected × Degree of Effect)		Estimated Time to Crisis *		
			1–5 yrs.	5–20 yrs.	20–50 yrs.
1.		Total annihilation	Nuclear or RCBW escalation	Nuclear or RCBW escalation	(Solved or dead)
2.	10^9	Great destruction or change (physical, biological, or political)	(Too Soon)	Participatory democracy Ecological balance	Political theory and economic structure Population planning Patterns of living Education Communications Integrative philosophy
3.	10^8	Widespread almost unbearable tension	Administrative management Slums Participatory democracy Racial conflict	Pollution Poverty Law and justice	?
4.	10^7	Large-scale distress	Transportation Neighborhood ugliness Crime	Communications gap	?
5.	10^6	Tension producing responsive change	Cancer and heart Smoking and drugs Artifical organs Accidents Sonic boom Water supply Marine resources Privacy on computers	Educational inadequacy	?
6.		Other problems—important but adequately researched	Military R & D New educational methods Mental illness Fusion power	Military R & D	
7.		Exaggerated dangers and hopes	Mind control Heart transplants Definition of death	Sperm banks Freezing bodies Unemployment from automation	Eugenics
8.		Noncrisis problems being "overstudied"	Man in space Most basic science		

* If no major effort is made at anticipatory solution.
RCBW—Radiological Chemical Biological Warfare.

TABLE 2

CLASSIFICATION OF PROBLEMS AND CRISES BY ESTIMATED TIME AND INTENSITY (WORLD)

Grade	Estimated Crisis Intensity (Number Affected × Degree of Effect)		Estimated Time to Crisis *		
			1–5 yr.	5–20 yr.	20–50 yr.
1.	10^{10}	Total annihilation	Nuclear or RCBW escalation	Nuclear or RCBW escalation	(Solved or dead)
2.	10^{9}	Great destruction or change (physical, biological, or political)	(Too Soon)	Famines Ecological balance Development failures Local wars Rich-poor gap	Economic structure and political theory Population and ecological balance Patterns of living Universal education Communications integration *Management of world* *Integrative philosophy*
3.	10^{8}	Widespread almost unbearable tension	Administrative management Need for participation Group and racial conflict Poverty—rising expectations Environmental degradation	Poverty Pollution Racial wars Political rigidity Strong dictatorships	?
4.	10^{7}	Large-scale distress	Transportation Diseases Loss of old cultures	Housing Education Independence of big powers Communications gap	?
5.	10^{6}	Tension producing responsive change	Regional organization Water supplies	?	?
6.		Other problems—important but adequately researched	Technical development design Intelligent monetary design		
7.		Exaggerated dangers and hopes			Eugenics Melting of ice caps
8.		Noncrisis problems being "overstudied"	Man in space Most basic science		

* If no major effort is made at anticipatory solution.

vironmental crisis can be solved by political action. Many do not see the potential or the need for solution by science and technology. Is it not likely that the same science that helped create those problems can help solve them?

We do have an important problem in the setting of priorities in science and technology. We have been somewhat flexible in our priorities in the past and, if social problems are badly in need of help, scientists should do something to help solve them. The priority in the sciences must, to some extent, be the solution of social problems. But let us also realize that today's science will not be sufficient to solve tomorrow's problems. If the world of the 16th century had diverted all its energies from science to the solution of immediate social problems, it seems likely that we would still be concerned about plagues and witches. The problems of previous centuries have most often been solved by the application of that which was discovered by the "pure scientist."

It is an unfortunate fact that the research scientist belongs to a minority group—one that has neither the will nor the knowledge to approach the general public. For *here* lies the real crisis of our times. Not the "environmental crisis," which, like those crises before it, can and will be cared for, but an even more serious problem—that of ensuring the existence of basic research in the sciences.

* * *

SALKIND: I do not have a prepared paper with me today, but I would like to say a few words concerning one or two points mentioned by Dr. Perrin and by Dr. Feld.

Dr. Perrin, in your very illuminating comments you touched on the increasing danger of thermal pollution. I wish to refer specifically to your discussion of cooling towers as a solution for thermal water pollution. Though it is ingenuous to generalize in this field, I would say that cooling towers *are* very important, but they can hardly be considered as panaceas to this problem.

And the following points should be kept in mind. Cooling towers present a rather unique problem on which practically no engineering progress has been made during the last hundred years. And they are something like the Model T Ford. Their efficiency is very low, we do not see any breakthrough so far, and the utilities are generally very reluctant to use them any more than they must. There are certain considerations raised by meteorologists: in highly industrialized and developed areas, where there are many cooling towers of large size in a small area, we may create undesirable microclimate changes, thunderstorms, and so on.

So far, no solution has been found to this problem. And that is only on the lighter side. You may know that the question of thermal pollution produces a fierce battle on a front of semantics—quite unexpectedly. The utilities and the manufacturers of equipment are most unhappy about the term "thermal pollution," which may spoil their business. And therefore several other terms have been suggested, such as thermal effects, or even thermal enrichment.

I fully agree with Dr. Feld about the importance of, let us say, reusing of garbage, which is not often realized, as fertilizer and for salvaging valuable metals. But recently I came across an old definition of waste and garbage. It is simply dirt that is misplaced.

Now, just a few words about air pollution: Witness the violent explosion of interest and concern, which is wholly justified, about water and air pollution. I sincerely hope that this topic will not be forgotten too soon, will not go out of fashion. It is not always easy to predict the reaction of the general public; and here I would mention an unexpected case about which I learned from a book published more than 100 years ago; the municipality of Madrid became concerned about garbage heaps in the streets and decided to remove them. But then a petition was sent to the municipality protesting this proposed action because, and I quote, "The air of Madrid was so sweet that it required something to temper it."

Also, many years ago, an old woman in a small town in England, when a new water supply system was inaugurated, was very distressed. She said, "This is not water, it has neither taste nor smell."

In conclusion, if you will permit, I will mention that some centuries ago a member of a very prominent family in England was fined twice for throwing garbage in the street. That was the father of William Shakespeare.

KORFF: There have been a couple of items raised during the course of the conference that I wanted to ask about. Perhaps Professor Perrin would be able to answer the first question, and that concerns the amount of tritium that comes out of reactors. There have been complaints from the conservation community about the amount of tritium that might come out of either breeder reactors or power reactors. Is that a big item?

PERRIN: Until now it has been a small item, but in the future, with breeders, precautions would be taken.

KORFF: Of course, with tritium there is the possibility of converting it to a solid by some chemical reaction; solids containing tritium are useful in research, so there is a potential market for them, which would offset some of the costs of keeping such agents as tritium and argon contained.

This problem of cost is something we have faced before: we can have a clean atmosphere if we are willing to pay for it.

The other point that I wanted to consider is the possibility of utilization of solar energy by laying panels out in the desert and converting solar energy directly into useful electrical energy. There have been some attempts at this, but solar energy has not yet developed as an economic source of energy. But, looking into the future, one certainly anticipates that there will be technical improvements in the processes; this would, of course, be a very nice form of energy. It produces no ash or other undesirable substances, and therefore it looks like a very useful direction in which we might go in the future.

Finally, I also want to comment on the question of thermal pollution. It is a very difficult problem in thermal dynamics to try to make use of a very large quantity of energy represented by a low temperature differential. It becomes extremely inefficient to use it in any way. On the other hand, the point has been made that certain biological processes occur much more rapidly with a quite small temperature rise; therefore the possibility exists of putting algae-breeding tanks next to one of these reactors that must dissipate energy and that produced a lot of thermal energy with a relatively small temperature differential. So here is another possibility of making use of the energy in this form, which otherwise is thermodynamically inaccessible to us.

PREGEL: I would like to make one remark on Dr. Perrin's talk. I find he is too optimistic in thinking that our fossil fuel reserves will last for 100 or 200 years; a few years ago at an international conference on peacetime use of atomic energy in Geneva, Professor Bhaba reported calculations to show that we will have fuels only to the end of this century. Of course, this is not enough; it is very important to remember that fuels are not distributed equally throughout the globe. There are certain areas where there is nothing, and it is a ques-

tion of transportation and many factors we do not usually take into consideration. We use only the global figures. I think we will have to go to atomic energy whether we like it or not, because other energies—solar energy and the energy of the wind and ocean tides—need not even be considered because, altogether, they do not account for five percent of the hydroelectric installations.

So we must go to atomic energy. I am not so pessimistic about nuclear wastes for a long time in the future because we have tremendous possibilities in the United States to deposit these wastes in ways that completely guarantee the prevention of any escape.

As to the recycling of the wastes, which my friend Dr. Feld suggested, in principle it is a very good idea, but we have to consider the great quantities of waste for the very small amount of metals we may be able to get from them. The economics of the exploration must be studied.

So, all these suggestions have to be weighed from an economic point of view to see if it is worth trying them. And we have to find other means for reusing or redistributing or annihilating our refuse.

CALHOUN: I would like to comment on the major engineering problem of our time, which has only been tangentially mentioned by the panel; this has to do with intellectual pollution, to which this august body is making its contribution, and to the companion task of engineering creativity. The major wealth is being transformed or refocused from the physical universe to the ideational universe, and this is where we need to focus and ask the question: "Can engineering contribute to production of creativity?" We have been playing around, and I think that is the right phrase, in our own laboratory for the last five years with getting rid of informational pollution, condensing information into particular topics that we are concerned with—into tautological statements—and then devising strategies that are a simulation of brain function as best we can understand them, to bring into association somewhat related tautological statements.

One is produced to lead to better insights about what the existing consensus of opinion is, and the second is to bring into relationship somewhat related statements, which then generate new insights. That is, to develop prostheses to the brain—for, after all, that is what evolution is all about, the increase in brain function, that is, the storage and transfer and transformation of information. I hope that some focus can be placed on this during our discussions and that we do not avoid this major issue in our concern with the physical aspects of engineering.

ERAJ: I am a gynecologist in Kenya associated with family-planning programs. I apologize for mentioning a problem. Some speakers here have referred to a projected population of 6 billion. Others have implied the development of such a population. As a matter of fact, we cannot discuss this problem in a gathering like this without really deferring to the mass of humanity we are going to deal with. I want to point out that the 6-billion figure is only a projection; it is not made on a scientific basis but has been clouded with personal opinions and other motives. Also, it has been suggested that the doubling of population is not real in the context of national considerations, today. It is not true in some nations.

I have a personal, selfish motive for raising this. The intelligentsia in the developing countries do not believe in these projections. As an obstetrician it diminishes my work, but as a family planner I know that these projections get in the way of family-planning programs. I think it is necessary for us to bear in mind that these projections are not based on any scientific analysis.

PECCEI: I must state before I begin my nonqualifications to speak here. I am not a specialist, I am not a generalist, I am not even a scientist; I am just a corporate manager. So I may say something out of line with what you think. I will touch two points; one a specific problem that has been discussed at this conference, and then the problem complex.

The specific problem is population. We have asked ourselves here—and everyone asks—questions about population, and all the questions are legitimate. But probably the essential question is not asked very often, and that is, is there an optimum population? Are we in a situation rather near to or far removed from an optimum population? And it is a question of numbers and distribution, as well as many other things.

But let us take numbers and distribution. Optimum or even acceptable population in relation to something—to what? Actually, it is in relation to the general situation, the circumstances we are living in, the opportunities and constraints, the body of knowledge, the state of the art of our different technologies, the organization and functioning of our institutions, the systems of values and beliefs, that we are activated by.

If we focus on the problem of population, we will see that we are very far from optimum conditions. There are mismatches, there are dissonances, there are imbalances practically all along the line. They are everywhere, not only in the Brazilian *favellas*, or in the *villas miserias* of Buenos Aires, or in the slums of our cities. There is an imbalance between the population and human expectations.

In the Italian cities or in Paris, where there is overpopulation without the possibility of providing education or hope, there is an imbalance between population and control of crime. In Egypt, there is an imbalance between population and land. In the U.S., there is an imbalance between population and availability of water. If we consider this general context, which is formed by outside factors *vis-à-vis* population, if we take this context as a given, and the population as a variable, we see that we are far from an optimal situation today.

In the past there was some adjustment to excess or to scarcity of population, but the adjustment was made at the cost of great human suffering: migrations, wars, conquests, colonization. If we look into the future, we cannot help seeing a much greater mismatch in population *vis-à-vis* the general context, the reality in which we live. Some probable adjustment would be made also at the cost of human suffering, but on an order of magnitude that is quite different from the past. I think we are discussing aberrations. If we just project population growth and reality and estimate that there will be 6.4 billion people in the year 2000, or 10 to 12 to 16 billions 60 years from now, we will see that it cannot occur; something will give way much before that because the mismatch —the imbalance—between population and the general context of things cannot allow it to happen.

And I think it is also an aberration to think that between now and the end of the century we will increase our energy consumption six times. Of course, if we choose to increase energy consumption, we will increase it by six times—if we can. But we cannot at the same time increase consumption of materials and metals, as pointed out by Professor McHale, eight times between now and the end of the century.

We cannot provide, at the end of the century, only four sheets of newspaper and four sheets of toilet paper to each living human animal, as Professor Waddington suggested, because that would be at the cost of all our forests. And we cannot, if we can provide food for that population—and Dr.

Brown said we probably can—we cannot provide shelter because the construction that would have to be undertaken between now and the end of the century to allow modern, proper shelter for the growing population is much greater than all the construction that has been done since Jesus Christ.

So there are certainly very great mismatches, and I think that if we merely project trends and make disjointed forecasts, we can only arrive at great confusion and perhaps at prediction of some kind of catastrophe.

Let me draw three small conclusions from this, taking one problem as an example in a general context that we usually ignore.

The first thing, a problem, a mismatch, a dissonance cannot be analyzed out of context. It has been said much better than I can by Professor von Foerster.

Second, what is this general context, this reality against which we have to consider each problem? It is the sum, the complex of the old mismatches, imbalances of all other factors.

And, therefore, the third is that a problem cannot be analyzed or attacked on its own terms alone but must be analyzed practically in terms of the general context.

From this I would go to my second major point: the general context is the problem context, and what we have now is an order of magnitude—the speed, the interactions that exist in today's world—and it requires a great effort in our thinking. Perhaps new dimensions have to be added to our thinking. There are three dimensions that I believe are essentials and that we sometimes use, but not in a correlative way, although they are correlative to each other; the first new dimension is the world dimension. World does not mean international; we should not talk about internationality instead of globality. It is a globality patched together with white thread. This is the easiest new dimension to acquire.

The second dimension is not spatial but temporal, meaning that we must look at new horizons, but this is not an exploratory concept, it is formative. It is practically useless to seek only where we might go. We must seek where we *must* go, where we *want* to go, where we *will* go. So the second dimension is much more difficult than the first. And we have not been trained to do that. Not only must we fight our own ego, but we must also be a little more intelligent. If we do not look very far ahead with a normative approach, the kind and numbers of options the next generations will have will be reduced at a certain moment; that generation will have only a few options, and perhaps we will see that the human animal has put himself out of business.

The third dimension is the systematic one, which is even more difficult to acquire because all our training, all our culture has been linear, sequential, cause-and-effect, and now we have to acquire the dimensions of the interactions. The three dimensions have to go together, and if we do not go together with the three dimensions, we will just consider some operation or some subsystem, thinking that we are solving the problem of the big system, which is the world.

UNIDENTIFIED DISCUSSANT: Professor Perrin, could you comment on the future of fusion as a source of energy?

PERRIN: Of course we know that another source of nuclear energy is fusion. But I think that practical applications of fusion will come much later. I would be surprised if we can really use fusion before the middle of the next century. It may be very important to prove its feasibility, which will be done probably during the next ten years, but before fusion becomes economically advantageous in comparison with fission, there may be a very long time. It would, of course, be very important to have fusion as soon as possible, but because of the possibilities of serious controversy over breeder reactors, I do not think it will come before a century.

UNIDENTIFIED DISCUSSANT: I have a question for Professor von Foerster. You stated that the questions of pollution and environment have not been considered before the current emphasis. In my country, Sweden, it has been quite different. These questions were discussed in the 1930s, and among those who have, in the last 20 years, been very concerned is Professor Heden, who is here. I think that perhaps the situation in Sweden has been that politicians have been aware of these problems but have regarded them as secondary. First they had to solve the problem of resources and afterward of cleaning up. My question, therefore, is: Don't you think that we have to delve much deeper into the process of decision by the politicians before we can proceed with the analysis that you and our Italian friend here have suggested?

VON FOERSTER: I don't think I really said that nobody perceived of the heuristic problem of looking into the environment. I thought I said that in this country, at least, suddenly people are aware that we are in an environment, and suddenly the whole thing becomes an issue of the press and radio and television, and suddenly everybody is talking about it. There is absolutely no doubt that all the perception of our environment has been deeply embodied in our cultural approach to things. Picking up a piece of paper or not is, I think, something that people were taught when they were children, how to clean up the mess in their rooms, etc. All these things are immediately and tremendously involved in seeing one's own environment, in keeping it clean or lousing it up.

I am sure that Sweden is, of course, one of the leading countries in being extraordinarily clean. It is one of the most delightful things to see those polished streets! But I do not think it is so much the vision or the position of the politician, at least as I understand the function of the politician. He is kicked by the people, and if the people do not kick him, they will make their own decisions.

So I think it is very healthy in this country that the perception of the environment has come about (in other countries it has been coming about for a long time) and it is very healthy that in this country suddenly people are aware and start kicking the politicians. Whether they will kick successfully remains to be seen. Whether the politicians or the public will desire to pay a little bit more for having clean air, of course, I cannot predict. But something is boiling, and I hope we will get some very clean countries.

MEAD: I would like to follow up what Mr. Peccei said and also the demurrers that have been brought in from some parts of the world on the population problem. I think that where we get into trouble is in making a gross statement about the entire world and failing to take into account the fact that we are not going to have the entire world cooperating in not having more than 6 billion people. This is not the order of cooperation that is possible; we have to have an effect that is relevant to every group of people who are self-identified and have some degree of economic and political autonomy. And that means, I think, that we must have an ethic that is equally applicable to the affluent countries and the very least populated or poorest countries, and it has to be the same ethic. But then it has to be applied in different ways.

To return to what Mr. Peccei said about an optimum population: if we had standards for an optimum population for any country, if we had enough

criteria, which would mean the present resources, present state of technology, present geographic pattern, present aspiration for one's children, all of which are very different in different countries, it would then be possible for each country to compute how close they were to an optimum population, and to ask for various kinds of help, if they needed it, to reach that position. We would not have to have this contrast between the poor or rich countries, or the over/or underpopulated countries.

Secondly, we keep talking about the fact that in the past we had war, we had massacre, we had plague; in the 7th century, we had bishops praying to God for a plague to destroy the inferior orders of man so that disease would disappear. I would suggest that we are substituting for war and plague—prayed for or just sent—and massacres, and we are trying to substitute a consciousness of what is happening, which will, in itself, provide the necessary brakes and deterrents. And that we are not emphasizing enough that this degree of self-consciousness, is the new brake on runaways that otherwise would go in a linear direction and do us a great deal of harm; it ought to be considered in the same light. I have been very impressed with the fact that groups are no longer willing to discuss famine, plague, or war as solutions. They simply are no longer willing to consider that these are possible solutions, so we have to seek another sort of solution, which is an internationally propagated consciousness of a new situation.

WOLF: I was very much impressed by what Dr. Mead said. She, in a very eloquent way, summarized the World Employment Program that the International Labor Organization launched last year to evaluate resources throughout the world in all countries in order to study job possibilities, job opportunities, creation of employment throughout the world, taking into account the demographic explosion, taking into account natural resources in order to integrate the economic situation and the social situation in a proper world balance.

May I also add that we are now trying to bring all the people of the different nations into the picture, and we recently discussed the possibility of participation of all people in a particular country in the development, the economic and social development, of the country in order to find the proper way to interest everybody in these problems. We emphasized the fact that the best spokesmen for the population are probably the employers' and the workers' organizations to start with, to try to focus the views of the people and get each deeply and directly interested.

MADDUX: I am John Maddux, from the World Bank. I want to congratulate Dr. Mead for her emphasis on the point that different people are obviously going to do the same thing in different ways. I don't think there is any sense in supposing that anybody is not going to have another child simply because they think there are going to be 6 billion people in the year 2000. I think that is psychologically unsound.

The World Bank is very interested in this problem as it relates to development, and what we need is to find innovative ways for different cultures to assess the problem in their own way and react to it in their own way. One of the original things that Dr. Mead mentioned recently in another meeting was the possibility of people in this country having one child of their own and adopting another child from another culture. And this idea is a marvelously creative and innovative idea that would not only help the population problem but help the cross-cultural problem as well.

I would make one other suggestion: I think one of the great difficulties with the kinds of contraceptive techniques that we have today, as they relate to women, are that psychologically they are negative. That is, a woman must continually make the decision not to have a child and must take some precaution not to have a child, whether it is the pill, or the IUD, or whatever the technique is.

I think it would be far more efficient if we could find a way in which a woman, when she wanted a child, took some positive action, and that is one of the promises of the implant. We all know that people take action, but I am talking about action that results or does not result in a child. The moment at which you take action is not a very good time to worry about the population figure for the year 2000. The beauty of the implant idea, at least psychologically, is that the implant has to be removed before conception can take place, and that is a positive decision that a woman makes and goes to some trouble to make that decision.

Today, all the contraceptive techniques involve women negatively. I think that is probably harmful. I don't know whether any study has been done from a psychological point of view. What we need are more innovative ways of attacking these problems in consonance with people's problems.

PERRIN: Of course, there are many questions to be considered on the vast subjects we dealt with here. We are just summarizing one point in connection with Dr. Mead's statement. Undoubtedly, sooner or later, mankind will have to limit its growth, and then, and very soon, mankind will have to choose, if we discard atomic war, between starvation and birth control. And I think we must face that situation.

WATER AND ENERGY 50 YEARS FROM NOW

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Water

Within about 50 years the population of the earth will be on the order of 12 billion inhabitants, or three times the present population. It is reasonable to predict an average figure of 1,200 cubic meters per person per year for combined domestic, industrial, and agricultural needs; actually, this figure has now been reached in the United States. Within 50 years, man's fresh-water needs will rise to 14,000 cubic kilometers. Because rivers carry to the sea less than twice this volume annually, and because of the irregularity of the flow of rivers and the enormous masses of water that, during great floods, are lost to consumers, we can see that rivers will be incapable of covering fresh-water needs of the world's population.

However, if we consider the total amount of the world's water resources, we see that:

—About 98 per cent is salt water (1,300 million cubic kilometers);

—of the remainder, the major amount is ice in the polar regions (25 million cubic kilometers);

—only a minute part of the total amount of fresh water remains available to man (0.350 million cubic kilometers of surface water and 0.150 million cubic kilometers of atmospheric water).

Fresh water resources are very limited; the only remaining sources are the seas and the oceans, which, because of their immense volume, are capable of providing for the needs of future humanity.

Man must, therefore, seek water from the sea, and, in order to utilize it, he must remove its salt, a problem of major importance with which every nation is concerned today.

I do not intend to burden this general discussion with a detailed examination of the various methods developed or studied for the desalting of marine waters and will confine myself to enumerating methods by separation (electrodialysis, osmotic process, electroabsorption) or by ion exchange. Both methods are effective in extracting salt from water, but neither appears economic for mass production of fresh water from sea water.

Methods separating the water from solution without changing its state, whether by solvent extraction (still at the laboratory stage), by hydrate formation, or by inverse osmosis, are too costly for the treatment of sea water.

Simple freezing necessitates washing of the ice with pure water to eliminate traces of salt water, which diminishes the return: the process can be aided by the use of butane as an auxiliary refrigerant.

Solar energy has also been used, but this method, which requires one square meter of effective surface for a daily production of three to four liters, is hardly suitable for high-volume installations.

Obviously then, mass production of fresh water from ocean water must be

obtained by evaporation-condensation. This process, the oldest, and used for a long time on ships, may utilize various techniques that seek to reduce the cost of operation and, principally, the consumption of energy. Among the techniques are use of long vertical tubes, lighting or "flash" distillation, steam compression, and "multiflash" by steam reheating.

Whatever the method, production of fresh water necessitates a large consumption of energy, thus explaining why the twin problems of water and energy are so closely related—indeed, inseparable. The oceans *will* furnish man with all the fresh water he needs, on the condition that he has available enough energy to extract it under acceptable economic conditions.

Energy

I would now like to review briefly the various sources of energy in the world.

Hydroelectric Power

The sun evaporates water from the continents and the seas; winds transport the clouds; their condensation feeds the rivers. Thus, the cycle of water and the rotation of turbines.

Installation of hydroelectric power plants is continuing in most countries but, already, saturation has been reached in many; in Asia, Africa, and South America gigantic projects, some exceeding 25 million kilowatts for a single powerhouse still await completion, but a maximum will necessarily be reached in regard to the ever-increasing expansion of needs.

Fossil Fuels

These combustibles (carbons and lignites, petroleum, natural gas) represent reserves of biological origin that have formed slowly over millions of years. The progress of science and technology is multiplying discoveries of new strata, thus constantly deferring the exhaustion of these resources.

Nevertheless, it is certain that the growing consumption of fossil fuel reserves, which are renewed only over many thousands of years, will necessarily lead to their total disappearance unless other sources of energy are developed.

Solar Energy

To approach this section one must discuss some of the characteristics of that sparkling star of which the earth is a natural or adopted daughter.

Although modest in rank among the billions of stars in the universe, to us the sun eclipses them all, because it is so near. What are the eight light-minutes that separate us—hardly 144 million kilometers—in contrast with the 52 light-months or the thousands of light-years separating the earth from some stars, or with the seven or eight billion light-years to the most remote sources up to now revealed in the universe?

How can we keep from dreaming, faced with such immense figures, when we consider that certain stars have perhaps disappeared thousands of years ago but we are still receiving the luminous testimony of their past splendor?

What lesson of modesty would poor human beings be able to draw from such a scale of dimensions, beings who are but minute dust particles on an earth whose diameter does not reach one one-hundredth of that of the sun?

It is true that, at the surface of the sun, a man of medium height, if he were not volatilized by an ambient temperature on the order of 10,000° F, would see his weight exceed two tons.

Leaving these various considerations, let us concentrate on the sun's prodigious energy capacity: its rays, in clear weather, carry a brute power of one million kilowatts to a terrestrial surface of one square kilometer.

Of course, in a given place, the sun does not shine permanently and utility plants, because of their feeble results or their high cost, allow recovery of only a fraction of the available radiation; however, immense possibilities are offered to us by solar energy.

In ancient times, the mirrors of Archimedes set ablaze the Roman fleet at Syracuse. Today, at Mont-Louis in the eastern Pyrenees, a solar oven of 100 kilowatts is radiated by a swiveling mirror covering 135 square meters; it automatically follows the course of the sun and lights a parabolic mirror of 15 tons, made up of 3,500 concave elements with a total surface of 90 square meters. A second solar oven, ten times more powerful, is now operating, also in France, at Font-Romeu. The bulkiness of the installation and the relatively low economic value of the power obtained is a drawback, but the quality of that power is exceptional: in the vat, where precious materials can melt, the mirrors concentrate a heat untouched by any impurity.

Once the Vestal Virgins lighted the sacred fire with converging rays caught in the hollow of a golden cup. Today, in a number of countries where the sun constitutes the principal source of energy, more prosaic apparatus, set up under very economical conditions, allows utilization of the sun for cooking food.

Between the Font-Romeu oven and the individual cooking stove, all sorts of apparatus of intermediate size have been adopted for feeding steam generators or maintaining cold storage, for heating buildings or controlling their air; in each case, through the intermediary of hot water, flat collectors with large surfaces slowly traversed by the liquid pick up the calories that come from the sky.

Silicon cells, solar batteries that, for economic considerations, cannot yet be adopted because of their low power, should also be noted. The day is probably still far off when automobiles will traverse the desert, propelled by such batteries; however, space engines are now using solar batteries to feed their electronic apparatus.

Because of the sun, one can, by photosynthesis, effect the intensive culture, in a liquid environment, of certain rapidly growing algae, the chlorella. These algae are combustible, as if they were firewood; they can serve man as nutriment, rich in proteins and vitamins; they can contribute also to the production of oxygen necessary to astronauts.

Finally, I would suggest the potentials of photocatalyzers in the dissociation of water by solar radiation and in the production of hydrogen that engines or gas turbines will transform into energy.

Having touched briefly on the various direct uses of solar energy, we must also note, to do full justice to the star of life, that we owe to it almost all the other sources of energy that we have at our disposal: without the sun, the water cycle would not exist and hydroelectric plants would cease operating; carbon and petroleum are only reserves of solar energy slowly formed through geologic millennia; winds find their origin in the sun, as does geothermal energy.

Note also that our debt to solar radiation goes beyond the level of energy: it is the basis of the functioning of chlorophyll in plants and, consequently, through vegetation and herbivorous animals, is the source of man's nourishment.

When, fascinated by the sun, we say that it represents half of life, the best half, we are still far from the truth.

Aeolian Energy

I would like to point out that air, weightless as it may seem, is actually a notable mass, as soon as the volume concerned is of some importance: if one were to find in any large crowd a Hercules hardly familiarized with such orders of greatness, he would perhaps smile at the thought of supporting on his shoulders the weight of the air within those walls.

From that point, with the scale of atmospheric masses and of the rapid currents animating them, we can conceive of the extent of energy brought into play by the wind, phenomena that can, in certain cases, provoke catastrophes. Limited generally to a diameter of about 150 to 200 meters, never exceeding one kilometer, terrestrial whirlwinds, tornados, narrowly concentrate frightening destruction in their path, uprooting trees, literally causing buildings to explode by the brutal fall of exterior pressure, drawing in other structures with irresistible suction. A few meters away, the ravaged zone borders one that remains firmly intact.

At sea, whirlwinds are even more impressive, for the depression in their central funnel draws in with a crash a frothy emulsion and raises this turbulent mass up to the generating cloud.

Whatever the damage caused locally by whirlwinds, it is far from attaining that for which cyclones are responsible. With a diameter of several hundred kilometers and speeds capable of exceeding 200 kilometers per hour for the rotating air, cyclones move slowly, usually at the rate of from 18 to 36 kilometers per hour, so that their arrival can often be foreseen. But, if the announcement of a cyclone allows populations to take shelter, it does not, on the other hand, authorize a slow-moving parade. Particularly dangerous near certain coastal areas, cyclones engender storms of exceptional violence, and the assault of their waves is similar to that of the hurricane.

Yet, if Aeolus subjects men to such harsh experiences, how valuable to them is the aid he brings them, even if considered only in the domain of energy. Thanks to him, well before propulsion by wheel or by screw was a reality, sailing vessels furrowed the oceans. They impose on our memories a dream-like vision, perhaps of the graceful caravels on which the brave captains of José María de Heredia left Spain and Portugal to gather the "fabulous metal that Cipango matured in its distant mines. . . ."

On land, wind has activated many windmills perched on hills for many years, and a few of these still remain in service. Windmills are decreasing in number, partly because of air motors; the most powerful of these yet developed,

with a force of 1,200 kilowatts, was activated by a two-bladed helix, 53 meters in diameter; cumbersome and fragile, it broke soon after being put into service.

Of greater interest in practice, however, are low-power wind turbines that drive an alternator and produce electrical energy; in this case, a battery of accumulators must be provided to assure service when the wind stops. On the other hand, the problem does not exist when, by mechanical transmission, the air motor drives a pump furnishing water for irrigation, directly or after accumulation in a reservoir.

Pending the time when sufficient knowledge of suitable sites is gathered and until the perfection of instruments leads to a more generalized use of air motors, these are already rendering valuable service in places far from other sources of energy.

Tidal Energy

Because of the pull of the sun and the moon, the sea levels undergo periodic oscillations. These are the tides, whose amplitude, variable from one point in the world to another, exceeds 15 meters at Davis Strait in Canada.

If today the origin of tides and their theory are known, their cause appeared mysterious to the ancients, and I cannot resist the desire to invoke the explanation of the great astronomer Kepler in the 16th century: according to Kepler, the earth was a gigantic living animal whose respiration provoked the flux and reflux of the sea; men and animals were "like insects or lice who fed upon the skin of the large animal."

The phenomenon of tides cuts terrestrial kinetic energy by almost 13,000 billion kilowatt hours per year and, thus, slows down, although imperceptibly, the rotation of the earth. Of this considerable amount of energy caused by tidal movement we draw today on only a fraction; France has opened the way in the domain of tidal power plants.

The plant at La Rance, with 240,000 kilowatts of power, produces 540 million kilowatt hours per year. It allows great flexibility of operations. Capable of functioning under good conditions either with turbines or pumps, the plant is liberated from a strict adherence to the tide schedules; the turbine is used at peak hours of the system, while power is accumulated by pumping during the slack hours.

However, the plant of La Rance is a small matter next to the vast project of Mont-Saint-Michel, which could, by itself, furnish France with 15 billion kilowatt hours per year, that is, one-third of the total she could draw on from her entire waterways system.

Outside France, favorable locations for tidal power plants exist in England, Scotland, the White Sea, Argentina, Korea, India, and Australia.

Thermal Energy from the Seas

The difference in temperature between surface water and the ocean depths easily exceeds 20° in tropical seas. Given the enormous liquid masses, man could have an inexhaustible volume of thermal energy for activating steam engines of considerable power in spite of the slight deviation of temperature. The value of thermal energy generated in this way is that it is produced under constant power.

Moreover, the evaporation of sea water liberates marine salt, and the condensation of steam furnishes a large quantity of chemically pure water: this last point, of course, is of considerable importance for the supply of fresh water to coastal regions of the tropics.

Unfortunately, construction of power plants using thermal energy from the seas requires deep waters very close to the coast; this condition narrowly limits the possible locations. Solving the problem by constructing floating power plants seems possible in certain cases, but many technical problems have still to be overcome.

An early attempt to harness thermal energy from the seas has been made by the French scientists Georges Claude and Boucherot, both pioneers in this field. But the project failed because of a rupture of the conduit in the course of installation.

More recently, research sponsored by Electricité de France has been undertaken with the hope of building an experimental 7,000 kilowatts station at Abidjan.

It is difficult at present to determine the extent of the potential development of power plants using thermal energy from the seas, but it appears certain that extensive applications will be attempted, particularly because of the possibility of considerable production of potable water at the site of the plant.

Geothermic Energy

Three billion years ago, a ball of fire moved across space: it was the earth. . . .

Little by little, this blazing mass coming into contact with the interstellar cold formed a superficial crust on which vegetable and animal life developed; under the precarious crustal envelope, the planet still shelters gigantic reserves of heat.

The central core, the barysphere, whose radius is greater than the distance between Dakar and Recife, has a temperature of 6,000 degrees according to some, much higher according to others. All around this core, at an elevation of 2,900 kilometers, extends the pyrosphere, whose upper stratum, 1,400 kilometers deep, is made up of a semipasty mass at more than 2,000 degrees, moved by very slow currents of convection. On this mass rests—floats, as it were, the lithosphere on which we live: this terrestrial crust, which has an unequal thickness, averaging 50 kilometers, is thinner in proportion to the globe than the shell of an egg is to the egg itself. The great fragility of this terrestrial crust, in comparison with the hot and moving mass that it imprisons, explains its distortions, its ruptures, and the cataclysms that these sometimes generate.

These volcanic eruptions periodically plunge humanity into mourning. In A.D. 79, Vesuvius buried Herculaneum and Pompeii. In Chen-Si, 830,000 persons perished in 1556. Etna, in 1669, killed 100,000 people. In 1783, Laki transformed one-tenth of Iceland into a desert and spewed a mass of stones, cinders and lava that would have uniformly covered Paris with debris rising as high as the Eiffel Tower. In 1883, the island of Krakatoa literally exploded, causing a tidal wave 35 meters high that drowned 36,000 inhabitants of neighboring coasts and transported ships several kilometers into the interior.

From Chile to Japan, entire cities have payed their tribute to earthquakes,

such as Agadir, Skoplje, and many others; the most frightening catastrophe of modern times occurred in Japan, which in 1923 killed 143,000 people, injured 104,000, completely destroyed 576,000 houses, and partially destroyed 126,000.

Thus, volcanic eruptions and earthquakes clearly reveal the destructive power of energy imprisoned in the terrestrial substratum. However, this energy can also have a beneficient characteristic; it can make a valuable contribution to man's welfare.

In many spas, burning springs with halos of steam gush forth. In Iceland, the capital and several other cities draw on geysers and thermal springs, not only to heat their buildings, but also for giant greenhouses in which are grown, less than 250 kilometers from the Arctic Circle, an abundance of vegetables and flowers, astonishing at such a latitude. In Italy's Larderello region, natural fumaroles and artificial pits furnish enough superheated vapor with high pressure to supply a group of thermal power plants with considerable force. At numerous places in the world, operations of the same type may possibly be realized.

Going further, certain engineers, Georges Claude in particular, have proposed injecting water deeply into the soil, via appropriate borings; this water would be heated in contact with the burning ground and would then supply powerful thermal stations.

Among all these there is a considerable potential of energy. A striking image of it can be obtained by considering the heat liberated by a very small cooling of the earth, cooling limited to 0.1°: this heat would be equivalent to the total world consumption of coal, at the present rate, for a period of 10 billion years.

Nuclear Energy

As has been shown, the sources of energy available to us suffer from various limitations: either they have a limited value impossible to exceed (hydroelectricity) or the reserves are certainly important but rapidly exhausted (fossil combustibles), or they are inexhaustible but very diffused, affording, therefore, low potential and difficulty in development (sun, wind, tides, thermal energy of the seas, geothermal energy).

Given these circumstances, the problem of the world's future energy needs was without a true solution until nuclear energy appeared. After a period of inevitable uncertainties, we are today, with all certainty, at the solution to our energy problem.

The known reserves of uranium, the constant discoveries of new strata, the appearance of new combustibles, and the progress of technology in nuclear plants promise continuity and growth of this source of energy, based on present methods for fission of heavy elements. When fusion of light elements is a reality to be exploited, the resources will become practically unlimited.

The development and utilization of nuclear energy has required a rather delicate adjustment by society, partly because of the newness of the domain and partly because of the multiplicity of problems to be solved, such problems, for example, as the elimination of radioactive waste materials. With eminently practical solutions at hand, the development of nuclear plants is increasing at an exponential rate.

Atomic batteries have been perfected, and the electricity they furnish costs

less than other sources of energy; and, the popular bias against the installation of atomic plants has declined with development of perfectly effective rules of security: an atomic plant pollutes the atmosphere less than a plant using conventional combustion.

Under such conditions, we can consider the battle for energy as definitely won by man because of the immense resources that are now available to him at competitive cost. The trend will be toward enormous complexes of 10 million kilowatts; the consumption of cooling-down water will be considerable and will necessitate the location of these giant plants on the coasts of the ocean.

As I have noted earlier, the problem of production of fresh water from sea water is itself solved as soon as the problem of energy is solved; the twin problems of water and energy will be all the more closely related in the future because the simultaneous production of both water and energy will take place in the same plant. The most economical solution will be, of course, the simultaneous production of water and electricity by a single installation called a "Nuplex."

During the summer of 1967, a combined nuclear station (fresh water/electric energy) capable of producing 4,000 cubic meters of fresh water per day by desalination of sea water began operating in California. Operating costs were clearly lower than with earlier facilities because of new techniques utilizing temperatures of 180° C.

This installation will serve as a model for construction of a plant of the same type that will produce 600,000 cubic meters daily and will be constructed on an artificial island, Bolsa, in southern California, near Los Angeles. It will generate 1,800,000 kilowatts. Operating costs, which will be completely competitive with traditional methods of electricity production, have been estimated at 0.25 francs/cubic meter of fresh water and 0.02 francs/kilowatt hour.

A Russian project for a combined station with an enormous reactor of 3,800,000 kilowatts will lead to lower prices than those already discussed and will make desalination feasible not only for urban use but also for irrigation.

Such coastal-area plants, with a source of nuclear energy of enormous unitary power, will be the ones that, in 50 years, will supply man with electrical energy and potable water from the sea. The nuplexes producing considerable electrical energy, have available in the sea the large volume of water necessary for cooling the reactors.

In addition to the resources thus created, the great availability of energy will prompt location of large industries in the coastal regions, where they will benefit also from the advantages of maritime freight.

Such low-cost energy production makes it possible to conceive of agricultural use by pumping water for the irrigation of nearby areas; the energy will also be useful in such processes as the large-scale manufacture of fertilizer by extraction of nitrogen from the air and in the transformation of bauxite into aluminum, salt into chlorines, natural gas into plastics.

A logical consequence of these benefits would obviously be a concentration of populations in the vicinity of the seas, where large cities will spread out. Apart from the tourist attractions, these maritime zones will also benefit, because of the marine winds, from the best conditions for the battle against air pollution.

Finally, in the ocean regions, the tides will increase the effectiveness of the battle against marine pollution.

PSYCHOLOGICAL ADAPTION IN A WORLD OF PROGRAMMED MACHINES

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What is a man profited, if he shall gain the whole world, and lose his own soul?

—Matthew 16:26

Perhaps the most important mental operations that man performs are those that mediate his psychological adaptation to the environment. Adequate individual psychological adaptation is an essential prerequisite for species maintenance. It requires the establishment of a viable dynamic equilibrium between the demands of an individual's internal and external worlds. As with most higher biological species, psychological adaptation in man relies partially on social institutions that are transmitted through the medium of culture. An individual, therefore, must adapt not only to the physical and interpersonal environments in which he finds himself but to the existing social institutions as well. Any radical alteration of the environment—including its social organization—necessitates a change in the dynamic equilibrium between the total environment and the individual.

These theoretical formulations suggest the value of studying the predictable effects of programmed machines on both social institutions and the physical environment, in order to anticipate some of the probable consequences on man's efforts to adapt psychologically. This paper describes a conceptual approach to the modeling of the future effects of full-scale automation on work—a single social institution, important in psychological adaptation, that will be radically altered. Although the study of a single social institution will provide very limited insight into a complex problem, the approach can serve as a paradigm for the study of others. Much has been written and much thought has been given to the probable effects of full-scale automation on employment, especially the negative consequences for the employee. The primary concern has been safeguarding the economic welfare of the workers—both those displaced and those not displaced. One approach to the potential economic problems of automation has been a guaranteed annual income independent of the individual's personal productivity. It may be feasible and even necessary to pay a man a decent salary not to perform a job. Another economic approach to the problem has been to generate an adequate number of jobs for the work force. This point of view was presented quite succinctly by A. H. Raskin[7] in a most sensitive and perceptive article. He stated that "Today we have two very distinct problems in trying to make sure that everyone will have a useful place in our work life. One is to protect the man or woman who already has a job and who worries about being nudged out of it by a robot. The other is how to make sure that there will be enough new jobs to accommodate the vast number of youngsters who want, need and must have a creative outlet for their energies and their aspirations and the freshness

of thought they can infuse into our jaded society." Apart from our degree of concurrence with Raskin's view of the jaded nature of our society or its potential salvation by nonjaded youth, there can be no denying that this is a more sophisticated approach than a guaranteed annual income. This approach explicitly recognizes that in our present society there are functions served by and values derived from employment that go beyond the simple economic returns.

There is a third approach to this problem that recognizes not only the existence but the overriding importance of several human factors. There are, for example, psychological benefits derived from real work that are at least as necessary to the maintenance of our social system as are the economic benefits.[1, 3, 5] In order to take a systems approach to this problem, we must place automation in its appropriate social context so that we can examine and understand its potential effects—positive and negative—on work. A systems approach is necessary if we hope to understand such highly complex and interrelated issues as the environment and society. If we ignore the multiplicity of interrelationships and deal with problems in solitary isolation, we run the danger of naïvely-planned, rather than spontaneous, disaster.

A traditional approach to problems at this level of complexity has been evolutionary—to muddle through and hope for the best. Through a time-consuming process of trial and error, followed hopefully by appropriate adjustment and correction, a satisfactory steady state is achieved in the system. This approach, with its underlying faith in the beneficence of an almighty Lord, may be adequate for a system only slightly perturbed or slowly evolving. The effects of automation, unfortunately, promise to be both profound and rapid. The probability is remote that we will have the luxury of enough time to muddle through.

Proponents of an evolutionary approach invariably make inspirational statements about man's striking adaptability. No such statement would be complete at the time this is being written without a reference to the flight of Apollo 11. Although the reference is emotionally moving, we should not ignore the simple fact that the astronauts brought much of their earth environment with them in rather elaborate space suits. Man's adaptability is indeed remarkable, but it has both limits and deficiencies. The environment in which man evolved over eons of time, and which produced its genetic selection pressures, differs so sharply from the environment of a technologically advanced society as to be almost unrelated. We are not saying that all deviations from the conditions of a prehistoric jungle are bad but that rapid and massive changes from traditional environmental sources of sensory, perceptual, cognitive, affective, and physiologic nourishment are dangerous.

In a very real sense, man's adaptability is unfortunate. An organism that either survives or fails to survive in a given environment presents a much simpler case than does man. For example, if air pollution wiped out a major part of the earth's population in a short time, man would be forced—if there were enough men left—to take effective measures of control. It is because most people are able to adapt to foul air with minimal immediate and/or obvious damage that the pressures that are brought to bear on the sources of pollution are not particularly great. Paralleling this adaptive "gift" of man, we find, however, a sharp increase in a variety of chronic degenerative diseases. Coupled with the endemic diseases of an advanced society—ulcers and hypertension—these are parts of the price man pays for his ability to adapt partially

to environmental changes. The unfortunate medical reality that ulcers—gastric and duodenal—are found increasingly in children suggests that the role of a negative environment in this disorder is being extended to additional segments of the population.

This trend is recognized by a number of outstanding scientists. Professor René Dubos,[2] at the 1969 World Health Assembly in Boston, commented on a number of these particular issues. He stated that "the evolution of biological mechanisms is far too slow to keep up with the accelerated pace of the technological and social upheaval of the modern world. . . . Today, everything changes so quickly that the processes of adaptation do not have time to come into play . . . the more a population is exposed to modern technology, the more it appears to be subject to certain forms of chronic and degenerative diseases . . . [Man] probably cannot adapt to the toxic effects of chemical pollution and of certain synthetic products, to the physiological and mental difficulties caused by lack of physical effort, to the mechanization of life, to the presence of a wide variety of artificial stimulants." In an interview following the meeting, he added: "Our *wealthiest* [author's emphasis] suburbs are so impoverished in the stimuli which they give to their children—the stimuli are so narrow, so objectionable—that these children will never develop their full potential."

As we have emphasized elsewhere,[1] man's ability to manipulate and thereby alter the environment to which he must adapt has developed much more rapidly than any changes in his psychological adaptive mechanisms. His technological skills have outstripped his adaptive abilities. This does not mean to say that man cannot survive at all in this artificial environment but, rather, that he survives poorly. There is no evidence that increasing per-capita income, life expectancy, and material comforts have produced a concomitant increase in happiness, well-being, or the distinctively human virtues. Although it can be argued that the goal of technological development is not to produce human joy, it does seem quite remarkable that none of these victories has been accompanied by a greater sense of generalized human satisfaction and contentment. If anything, the opposite seems to be the case. Man appears to be better equipped to struggle against natural forces than he is to triumph over them. It is as if in this arena, too, man wages war more effectively than peace.

An opposite approach to such highly complex problems has been revolution; that is, to follow a charismatic leader who believes he has the answers to questions that have not yet been articulated. Answers in the absence of questions are not often productive but can serve to reduce anxiety. The charismatic leader traditionally is able to guide his followers only into deeper difficulties, although he is characterized by never losing his certainty, his "cool," or his charisma.

In spite of the inherent limitations of man's mental apparatus, closely reasoned, logically determined change offers the preferred and the only real alternative to both evolution and revolution. Many interactions will not be anticipated and others will be estimated incorrectly. The models we construct will of necessity be inadequate and unrealistic, but they are still preferable to anything else available. There are a number of qualitative and quantitative changes in the nature of work that will be produced by automation. This paper describes a schematic model in which the most immediate effects of automation on employment are postulated. From each of these, the subsidiary consequences—both secondary and interactive—are derived. By continuing this process, a model of probable consequences and interactions is constructed that highlights potential problem areas. Theoretically, values can be assigned that express the strength of certain of these relationships, thereby producing a variety of numerical results. The present state of knowledge concerning the measurement of the social variables in question—and their interrelations, is so meager that although such an assignment of values is feasible, it is premature. However, even a simple qualitative examination of the schema can be productive.

The effects of automation on employment are related to a variety of other factors, including education, population size, and feedback effects; ideally, they should be included in the model. Initially, it may be wiser to de-emphasize the consideration of feedback features in the model until further data are gathered. This technique of pyramidal schematization need not be restricted to work but can be used to model conceptually the effects of programed machines on a variety of social institutions that impinge on man's psychological adaptation, thereby ultimately creating a large, complex, interacting model that may adequately simulate the real system. The predicted consequences are not inevitable but only probable in an economy that has not been planned to anticipate them. The goal of modeling this system is to increase society's ability to produce rational options with known costs and benefits. The critical feature of this approach is the emphasis on the quality of mental functioning; in that sense it represents an attempt to introduce traditional humanistic concerns into our scientific deliberations.

It should be emphasized that we do not consider the industrialization and increasing mechanization of the first half of the 20th century in the United States to be automation. These industrial changes are historical precursors of automation, but they differ from it qualitatively and not just quantitatively. Nevertheless, they shed light on some of the probable effects of automation. Our concern is with computer-based automation, which has only begun to make its impact felt. Total production processes, through the packaging and invoicing of the final product, can be automated with the present state of the art. We must look carefully at selected industries, e.g., the petrochemical, in which large-scale automation has begun, for prodromal signs of the anticipated disorders.

The first level of predictable consequences of automation on the quantitative features of employment will include changes in productivity, work hours, and number of jobs. We can predict, with a high degree of confidence, an increase in both individual and national productivity in a fully automated society. There is clear evidence that productivity has been increasing in most technologically advanced Western societies for a number of years, and automation should enhance rather than reverse this particular trend. With this increase in individual productivity we can safely predict that the purchasing power of the individual worker will also be increased. The weight of the evidence is quite clear that the American worker will continue to receive a major share of any increase in his productivity or in the gross national product. The bargaining and political strength of American labor unions and the general trend in our society toward a more equitable distribution of wealth should insure this outcome. This increase in purchasing power will open a number of new options for the use of available leisure time.

Probable consequences of an increase in national productivity are an increase in industrial sources of environmental pollution and a further drain on

limited natural resources. Pollution is a good measure of the gross national product of a society and, therefore, of its technological capability. It is not difficult to anticipate that, as personal income rises, individual sources of pollution and resource consumption will also rise. An American living in our present value system who receives greater wealth will spend it on additional items that consume power and other natural resources, e.g., summer homes, automobiles, snowmobiles, boats, etc. Obviously there are a variety of possible social, political, and scientific counterforces to this consequence, such as pollution control and the development of new sources of energy. Many pollution problems are undoubtedly soluble, but they will not simply solve themselves. The effect, if any, of this increase in productivity and purchasing power on population size is uncertain. Financial success has not been consistently associated with family size in the past; more recently, the relationship between socio-economic status and number of children has become more complex and includes additional variables. There is no *a priori* reason for assuming that the "average" person will have a larger family if his real income goes up. On the other hand, an increase in purchasing power in conjunction with some of the factors that will be described later may tend to influence family size.

To return to the first-level consequences of automation, the second quantitative feature to be considered is the length of the work week. The basic work week, as opposed to the number of hours actually worked, has been going down slowly since the turn of the century. It is not certain that automation will, in itself, produce a shorter work week for all, but the probability is high that there will be displaced workers who are unemployed, underemployed, or paid to stay home. When automation's effects are coupled with the pre-existing trend in our society, a shorter work week becomes highly probable. The objection can be raised that individual workers are at present working more hours than they did ten or twenty years ago through overtime and moonlighting. This argument rather begs the question that the basic work week will continue to diminish. If a man chooses to increase his working hours beyond the basic week, through a variety of means, we must ask if his motivation is solely economic. This is a separate question that will be explored later.

The predictable diminution in work hours will have certain secondary consequences, such as an increase in the amount of leisure time. Some workers will choose to use this "leisure" for additional work; others will not. The need to develop satisfying and growth-promoting uses of leisure time is very likely to become increasingly important. The reduced number of hours spent on the job results in a corresponding diminution in time spent in relatively structured activities; less structured activities will probably take their place, e.g., recreational. Man's psychological adjustment is affected in highly individual and varying ways by the ratio between structured and relatively unstructured activities in his day.[6] The trend toward less work, in combination with prepackaged leisure-time activities—e.g., television—can combine to produce an increasing homeogeneity of perceptual inputs, both in variety and intensity. That this alteration of perceptual-pattern input may play an important role in mental adjustment is suggested by sensory-deprivation studies.

Any sharp reduction in the number of hours worked weekly or in the total length of the work life must be accompanied by a diminution in the quantity of work-related sources of satisfaction and work-related opportunities

for the acceptable discharge of drives that are otherwise socially unacceptable. Clearly, there would be a complementary increase in the amount of time for leisure-related satisfactions and leisure-related drive discharges. Unfortunately, Western man has more experience with the use of work as an adaptive device than he does with the use of leisure time. In our technologically advanced, Judeo-Christian society there are very few people who know how to use leisure time productively. Enforced early retirement is usually a euphemism for imminent death. On the other hand, the increased purchasing power available will make it economically possible for people to utilize this leisure time in a greater variety of ways, some of which might support adaptation.

The final first-level consequence of automation on the quantitative nature of work is the number of jobs. Full-scale automation will result in a reduction in the number of jobs per unit of population and in an even greater reduction in the number of particular types of jobs. The unique combination of psychological and physical frustrations and satisfactions that a particular job offers cannot be matched so easily by another. An enormous asset of the broadly based technological society in America has been the great variety of jobs available to meet the differing dynamic combinations of economic, physical, and psychological needs of workers. At a time when the population is increasing both in size and in heterogeneity, we can ill-afford any loss in job diversity. Yet the most unskilled and the most physically taxing jobs will be automated out of existence, as will be a variety of clerical, managerial, and so-called white-collar jobs.[1] This not only will lead to further structural unemployment but will markedly reduce the range of job satisfactions. The selective diminution in the range of skills necessary for the running of a highly automated society means that there will be a number of individuals who are unemployable.

If we concede that there will be a reduction in the total number of available jobs per unit population, a highly probable consequence will be the further deferment of young people's entrance into the work force. A "traditional" method of limiting the potential work force has been discrimination. As we move toward a more equal society there will be great pressure from ethnic and racial-minority groups for their fair share of the job market. An even larger group who have been systematically discriminated against are women. There are a variety of social and political pressures developing for equal job opportunities for women. The success of these efforts will only intensify the problem because any reduction in employment discrimination will increase job demand without increasing supply.

The draft has been an effective means of temporarily postponing the entrance of many young men into the work force. For some, this has been a relatively permanent postponement, because certain individuals have chosen to remain in military service. There are powerful influences in our society to reduce the size of standing armies and to terminate the draft. If these efforts are successful they will contribute to the imbalance between available jobs and available labor.

The raising of the general educational level—education lasts longer and is available to a larger proportion of the population—has been an important means of delaying entrance into the job force. Obviously, if this is to be an educational experience and not professional baby-sitting, there will be a need for drastic revamping of curricula. It is unrealistic to expect that the form of higher education that evolved to satisfy the needs of a small, élite subset of

the population can be extended, basically unaltered, to large numbers. If education is not to be a transparent device for frustrating young people's legitimate desire to enter society as full and productive members, it may have to be radically altered, made interruptible, and perhaps even shortened for many.

Automation will create new jobs, but the weight of the evidence is that it will produce fewer than it removes. There can be no question that the jobs it creates will be of a totally different character from those it terminates. Economically, the problem of the displaced worker is primarily one of maintaining his income at, or above, its previous level. Experience indicates that only one out of three such workers is successful in doing this.[8] With the increased productivity that a fully automated society promises, it may be possible to maintain income without creating an undue economic burden on the society. On the other hand, we do not know how large a nonproductive population any country can tolerate without endangering its economic viability. The economic realities of industrialization necessitated an increasing urbanization of society. The diminished need, in an automated society, for the geographic concentration of population near the means of production, along with the reduction in work force and working hours, will make it economically possible to achieve a more rational distribution of people over the available land. The psychological aspect of the displaced-worker problem is more complex than the economic. Some workers can be retrained, but this is not always feasible or even theoretically possible.[8] It is incorrect to assume that anyone can be trained to perform any task. The physical and mental limitations of the displaced worker must be considered, especially because a large percentage will be from the lower half of the I.Q. distribution. It is unrealistic to assume that they can be retrained, with our current knowledge of educational methods, to perform the needed and prestigious jobs of the automated society. The danger of producing a new social class of individuals who are able to understand and thereby control automation is quite real. This raises the potential problem of creating a new—technological—aristocracy.

Certain experiences with job retraining have proved most discouraging, though some have been more successful. When the job for which a worker is being trained does not differ substantially from the one he previously performed, the task of retraining, including psychological adjustment, is minimized. Retraining a man who has done hard manual labor to sit in a chair watching a gauge is not easy. It is not just a matter of his intelligence and ability to comprehend the new technology but also of his psychological needs, value system, sources of external gratification, role identity, etc.

These considerations suggest the importance of examining some of the effects of automation on the quality of work. Automation will continue the trend established by industrialization to reduce the physical effort expended by the worker on the job. There is a relationship, the exact nature and strength of which is unclear, between muscular effort and health—both physical and mental. To maintain good psychological adaptation, man needs to use his muscular system.[6] Menninger[5,6] argues that work is a uniquely valuable social institution for the constructive use of aggressive drive-energy. The element of struggle implicit in dealing with problems on the job may permit at least partial discharge of aggressive drives. In the job situation, it is often acceptable to become quite angry at an inanimate source of frustration. To curse a tool or to kick a machine that fails is not seen as a sign of illness but is accepted and even applauded. The probability that much of the

socially acceptable discharge of anger that takes place in these work situations owes its origin to nonwork-related problems must be considered. If work serves as a socially acceptable outlet for aggressive energies, then the loss of this outlet would result in an increase of aggressive behavior. Evidence in support of this position includes the relationship between unemployment and violence in American cities and the fact that strikes are frequently the occasion for violence. Clearly, a more rigorous examination of this question is required.

In addition to the hypothesized aggressive drive-discharge function of work, there are a variety of more highly visible psychological benefits. Hard manual labor has been a traditional source of masculine pride and self-confidence for many men. There is clinical and census-data evidence to suggest that men who are unemployed or underemployed often compensate for this by refusing to practice birth control and fathering large numbers of children who are visible evidence of their manliness. The problem of a selective increase in population pressure as a result of a loss of the traditional sources of support for masculine identity for certain socioeconomic groups must be considered. The value system and ethic that sees man as earning his right to exist and to consume through the sweat of his brow must change, or else man must continue to derive substantial narcissistic support from the experience of working. Our value system has changed enough so that most men can be proud of working with their minds, although in some groups this is still seen as less masculine. These changes are not enough. The values inherent in such roles as breadwinner and/or head of the household may not be compatible with the realities of a highly automated society.

Some of the psychological satisfactions that man gains from work derive from task mastery and the resulting sense of competence and completion.[1] The solution of new problems is obviously a source of much satisfaction to many workers. Performing a task in its entirety—i.e., carrying it through to completion—is also an important source of satisfaction. An unfortunate consequence of the assembly line, with its repetitive performance of the same subtask, has been the removal of much of the challenge and the sense of completion in work. There can be but little feeling of task mastery in the absence of both a challenge and a task. A man who is challenged in his work and is successful feels more satisfaction than a man who is not challenged at all. Needless to add, a man who is challenged by his job and consistently fails is in an even more unfortunate situation.

The various ways in which work currently serves to support a man's psychological adjustment must be better understood if we are to avoid the consequences of naïve action in this area.[1] Automation threatens to disrupt the dynamic equilibrium that presently exists between people and their work. This paper has described in considerable detail some of the highly probable effects of automation on both the qualitative and quantitative features of work in an economy that has not been planned to anticipate its disruptive potential. The consequences are presented as a schematic model because this arrangement not only highlights some interesting relationships but theoretically permits quantitative manipulation as well. The computers that will create the problems offer the technological basis for their possible solution. Electronic computation is a powerful tool whose potential for the solution of problems in these areas is real but undemonstrated. It is certain, however, that the mind of no given individual can retain, let alone manipulate, the number of varia-

bles required for the modeling of complex social systems. Computers, with their virtually unlimited memories and remarkable capacities for high-speed calculation, can be programmed to do the cost-and-benefit analyses that are necessary for the production of socially viable options. Finally, man not only must create the models that computers will use but must imbue them with his value system. It is not enough to provide for man's continuance as a biological species; we must insure the preservation of those distinctively human qualities that we treasure.

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COMPUTING IN THE SEMANTIC DOMAIN

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"Environment" appears in three distinct domains: in the domain of the "real world" (W); in the domain of "cognitive processes" (C), which provide an organism with an internal representation of his surroundings; and in the domain of an organisms "descriptions" (D) of his world. Environment is the triadic relationship E(W,C,D) between these domains.

From this, three dyadic relations can be derived. R_D(W,C), which is determined by an organism's perceptive potential and gives rise to complementary concepts as, e.g., "niche" and "instinct", "reality" and "consciousness"; R_C(W,D), which is determined by an organism's behavioral potential, and gives rise to complementary concepts as, e.g., "territory" and "control", "objects" and "names"; and R_W(C,D), which is determined by an organism's cognitive potential, and gives rise to complementary concepts as, e.g., "volition" and "action", "conceptions" and "propositions".

While these dyadic relationships have only recently been discovered as initial but essential steps in comprehending the holistic concept E, it is only descriptions, D, of single domains in isolation, the "major disciplines," as "physics" D(W), "psychology" D(C), "linguistics" D(D), and so on, to which the scientific community is accustomed to addressing itself, and for which powerful analytic formalisms have been developed.

Of the many causes that may have led to the contemplation of these domains in isolation, two appear to have exerted a major influence in this development. One is that in dyadic relations of the kind described above the observer always appears in his descriptions—i.e., is implicitly or explicitly making statements about himself.

However, "self-reference" in scientific discourse was always thought to be illegitimate, for it was generally believed that The Scientific Method rests on "objective" statements that are supposedly observer-independent, as if it were impossible to cope scientifically with self-reference, self-description, and self-explanation—that is, closed logical systems that include the referee in the reference, the observer in the description, and the axioms in the explanation.

This belief is unfounded, as has been shown by John von Neumann,[1,2] Gotthard Gunther,[3] Lars Löfgren,[4,5] and many others who addressed themselves to the question as to the degree of complexity a descriptive system must have in order to function like the objects described, and who answered this question successfully.

The other cause for the increasing compartmentalization of knowledge into "major disciplines" is that the syntactic relations in all logicomathematical formalisms are reasonably well understood, while the semantic relations that underlie formalisms as expressed, for instance, in natural languages are only recently being investigated and are as yet little understood.

On the other hand, it is clear that the tautological transformations *per se* within a logicomathematical formalism cannot lead us to new insights by

providing "solutions" to a "problem" (As long as no errors in calculation occur, they are just equivalent paraphrases.) unless by such paraphrasing new semantic relations become uncovered (the solution), which were opaque in the original formulation of the state of affairs (the problem).

Consider, for instance, The Ecological Problem. It consists of identifying n variables x_i $(i=1,2,3.\ldots n)$ and $n+mn^2$ parameters $A_{i\mu}$ and a_{ij} $(\mu=0,1,2.\ldots m)$, and "solving" the set of n simultaneous, ordinary, first-order differential equations with respect to time, t:

$$\dot{x}_i = \sum_{\mu=0}^{m} A_{i\mu} \left(\sum_{j}^{n} a_{ij}\, x_j \right)^{\mu} \qquad (1)$$

with the convention:

$$a^{\nu}_{ij} \equiv a_{ij\nu}$$

and, sometimes, with the popular constraint:

$$m=2\,.$$

This means expressing Eq(I) in the form of:

$$x_i = F_i\,(t, [x_{ok}, a_{kj\nu}, A_{k\mu}]), \qquad (2)$$
$$(i,j,k=1,2,\ldots,n);(\mu,\nu=0,1,\ldots m)$$

where the x_{ok} are the n initial conditions.

At this moment it is beside the point to ask whether Eq.(1) indeed constitutes the formulation of the ecological problem, that is, is there a valid model of the ecology underlying this expression in which the various parameters and the quantitative relations between the variables can be justified. (In fact there is none! This expression has to be taken as a "first principle.") The question here is whether or not the insight gained by contemplating Eq.(2) is more valuable than the insight lost by formulating Eq.(1).

It has become abundantly clear today that, although for small values of n and m $(n<5,\ m<3)$ valuable information of the behavior of such systems can indeed be gained, for large values of n and m, the opacity of the "solution" becomes commensurate with the opacity of the "problem," even if powerful computers are used in the study of such systems. If, on the other hand, "simplifying assumptions" are made that distort the original problem to such an extent that all connections with a reality are lost, the relevance of such studies becomes increasingly questionable.

How to overcome this dilemma is now the question.

There appear to be two avenues that will allow these difficulties to be bypassed. One was taken by physicists when they contemplated the thermodynamics of aggregates of very many particles. The idea is to forsake voluntarily the detailed available knowledge of the equations of motion of all the particles involved, and to develop measures of certain aspects of the system as a whole as, e.g., its energy, entropy, enthalpy, etc. Similarly, the systems engineers are content when they derive such notions as, e.g., uncertainty, redundancy, transmission, etc., which characterize in quantitative terms some general aspects of the systems under consideration.

The other possible avenue has been opened recently by our beginning to understand the relations between semantic and syntactic structures, and by the

development of computer systems of unprecedented power[6] together with relational program structures of unprecedented sophistication.[7] The idea is to abandon the strategy of reformulating the problem into terms that smack of mathematical rigor but lack the contextual richness originally perceived, and to develop the algorithms that transform the descriptions of certain aspects of a system into paraphrases that uncover new semantic relations pertaining to the system as a whole. This is computation in the semantic domain, rather than in the syntactic domain of logicomathematical formalisms. Here the possibility is opened for inductive inference, a logical modality that is denied all formalisms that rest on the infallibility of the tautological transform.

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RECENT ADVANCES IN ENERGY SYSTEMS

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Within the frame of the Conference on "Environment and Society in Transition," this report will consider the recent advances in those energy systems that convert energy from primary sources into thermal, mechanical, or electrical energy available for utilization. Advances likely to become practical, or even those which appear to have some possibility of becoming practical within the next ten or twenty years, should also be considered. The main object of this presentation is to determine how much these advances can help meet the growing requirements of mankind, in advanced or in developing countries, and how they may improve or worsen the various pollutions that result from the conversion of the primary energy.

The Importance of Energy for Mankind

Men, like animals, have always had food as their fundamental source of energy to keep them alive and internally warm and to enable them to move or do mechanical work. The mastery of fire was so important for early men that it identifies the rise of the human condition above that of animals. Fire meant warming in winter, lighting at night, and the possibility of improving food by cooking. The primary source of energy was then the chemical energy that could be released as heat by burning vegetable or animal fuels, such as wood or fat; this energy, as that of all foods, was the energy of solar light stored by living organisms. No other form of energy was mastered by men for thousands of centuries.

It was only during the neolithic period, less than 10,000 years ago, that men discovered the possibility of supplementing their own strength by that of large domesticated animals, such as cattle or horses, to plow fields, transport heavy loads, or move themselves at an increased speed. At that time began the use as fuel of dry dung—still the principal source of energy of large sections of mankind. This archaism is worth remembering at a time when nuclear energy is becoming prominent in other parts of the world.

At the end of the Roman period, the development of watermills for grinding grain was a more important factor than Christianity in the general abolition of slavery. But during the Middle Ages, only the windmills added something to these early sources of energy, though the use of black powder as a propellant in firearms in the early 14th century should be mentioned: its use for blasting in quarries appeared only in the 17th century.

Burning coal instead of wood to produce heat, which began very early, was done on a significant scale only after the beginning of the 18th century: it was then also that coal was first used to produce iron in the blast furnace. The great importance of coal as a fuel started with the development, during

the 19th century, of the steam engine, which partly converts heat to mechanical work.

The coal-burning steam engine was the main factor of that large increase in industrial production during the 19th century called the industrial revolution. From the middle of the last century, the discovery of the fundamental laws of electromagnetism lead to the possibility of converting, on a large scale, mechanical energy into electrical energy, cheaply transported and distributed to scattered small or large consumers. Electrical energy is the most versatile form of energy, because it is easily converted to light, heat, motive power, or chemical energy. First produced and used essentially for lighting, then for traction in city transportation (streets cars and metropolitan or underground railroads), its production as an intermediate between any kind of primary energy and utilization has become more and more general, leading to the disappearance of small stationary steam engines. It is still developing very fast.

It was also during the second half of the 19th century that petroleum production began, with lighting as its main utilization. Since the beginning of the 20th century, the development of automobiles has been associated with the use of gasoline from petroleum. Today petroleum is mostly used as a source of gasoline or of diesel oil for truck, car, or ship propulsion, and of fuel oil, competing with coal for power production or in homes for central heating. It should be noted that the fast-growing production of natural gas, which can be transported over long distances by pipe lines or by tankers (as liquid methane) and distributed for local heat generation in factories or homes (for warming or cooking) is becoming a more and more important factor in the total primary energy derived from fossil fuels.

Forecast of Future Energy Consumption

In the past, the raising of the level of living of any population has been closely connected with the increase of its consumption of energy. It is certain that improving the standard of living in underdeveloped countries will be possible only with a large increase in the amount of energy available in these countries, both for industry and for individual consumption. Even to maintain their poor present condition, their consumption of energy should at least follow the rapid growth of their populations. In the case of the most advanced countries, such as the United States, one might think that there would be no great pressure to increase the utilization of energy; but it is so much easier to make possible such an increase in these countries that no saturation is yet apparent, and power consumption in the advanced countries will probably continue to grow at the present rate, at least in the near future.

To speak of the growth of the energy requirements of mankind has no real meaning. A fundamental need for much more energy already exists in the large population living in underdeveloped nations. The problem is to estimate the probable development of the effective consumption of energy in different areas of the world and the future availability of primary energy supplies necessary for this development.

Analysis of the factors governing the increase in energy consumption is very difficult, especially in underdeveloped countries. These factors, like

availability and "cost" of capital for investment, education, and training of specialists, general industrial development, etc., are very intricate, and one must remember that the amount of energy consumed per capita in any population is both a measure of its wealth and by itself an important factor in the possible growth of that wealth. Attempts based on such analysis have not been very successful in the past, and global predictions by extrapolation of the observed growth of energy consumption in countries having reached different stages of industrial development seem more reliable.

In fact, during the past 50 years, the consumption of energy, in the different forms delivered to consumers (fuels, electricity, gasoline, has grown exponentially (constant rate of yearly increase) in the whole world as well as in more or less industrially advanced countries. This trend has been strikingly well followed by the consumption of electricity, which has been, throughout this period of half a century, multiplied by two every ten years (five periods of doubling, meaning a factor of more than 30). The consumption of gasoline for automobiles is also approximately doubling every ten years, while the direct consumption of fuels, as such, has been growing more slowly, doubling in about 25 years. Thus, the total consumption of energy is increasing faster now than 50 years ago, its period of doubling having decreased from about 30 years to about 20 years.

It is thus very tempting to estimate future consumption of energy by extrapolating these exponential laws, but it would be very hazardous to do this for more than one or two doubling periods. Obviously, the present rate of increase cannot continue for a very long time: electricity production doubling every 10 years for seven centuries would require, according to Einstein's law, the annihilation of the whole earth, its entire mass being converted into energy!

Forecasts deduced from exponential extrapolation during the next 20 years are probably not far wrong, and decisions may be based on them. Here we will just note that, in comparison with present figures, the electrical energy produced in the whole world will be multiplied by four at about the year 1990, while the total consumption of energy at the same time will be multiplied by three.

For the more distant future, the uncertainty increases rapidly, but we may consider a fairly good prediction that, by the end of this century, the annual world production of electricity may be six to eight times what it is in 1970, serving a world population that may have doubled. It should be remarked that a total energy consumption proportional to the world population should not be expected: on the contrary, it is likely that a smaller rate of increase of the world population would correspond to a higher rate of increase of the total energy consumption, because the standard of living in underdeveloped areas would be higher if the rate of population growth in these areas was reduced. Thirty years from now, the standard of living of a large fraction of mankind may be much lower than that of western Europe a century earlier.

What the situation will be one generation later, around the year 2030, is extremely uncertain, though it is the near future for mankind, which most of the children now living—our grandchildren, for men of my age—will see. If there is no social catastrophe resulting from an unchecked population explosion, or from atomic war, a large increase in the demand for energy is still to be expected during the first decades of the 21st century.

* *Recent or Expected Advances in the Utilization of Energy*

This heading covers not only the increase in the global efficiency between any primary source of energy and its final utilization but also new significant use of energy contributing to the general welfare of mankind.

A first, very important example of a considerable increase in efficiency is shown in the substitution, for warming houses, of central heating for open-hearth coal burning. In this case a multiplication at least by three of the efficiency has not led, in general, to a diminution of fuel consumption but to an increase in comfort. Similarly the consequence of a very large increase in the yield of electric-light bulbs is more light rather than less electricity consumed.

On a larger scale, the development of district central heating has, on the contrary, an important influence on the consumption of fuel used as a source of heat, first because it makes possible the use of low-grade or even apparently worthless fuel, such as garbage, which must be burned for disposal, and second, because the size of the heat-producing unit is sufficient to make the use of back-pressure turbines profitable, associating the production of hot steam, adequate for heating purposes, with power production. The use of back-pressure turbines to provide heat in large chemical plants may also result in an important saving of fuel.

In the future, added fuel saving will result from further improvement in the efficiency of heat conversion into electric power. Some progress in the steam cycle is still possible besides the diminution in the cost of conversion due to larger and larger production units of more than one megawatt per generator. Still greater efficiency may be attained when technological progress makes it possible and advantageous to start the conversion cycle at a much higher temperature, either by using gas turbines (with open or closed circuits) or by introducing a lithium-vapor cycle preceding an ordinary steam cycle.

The so-called direct conversion of heat at high temperature into electrical energy, requiring no moving gear of any kind, may also be used in the future to improve the total efficiency of heat conversion. For large power stations, the only direct conversion principle that seems promising is based on magnetodynamics (MHD). It might become economical to use a MHD cycle to precede a conventional steam cycle if the price of fuel increases markedly.

Technical progress, which is thus making cheaper and facilitating the conversion of primary energy and its distribution, is also the principal factor increasing the demand for more energy because of the new possibilities created for raising the standard of living. Among these possibilities, the development of small, efficient cooling units that can be installed in any house connected to a power grid is particularly significant for the underdeveloped countries, most of which are located in tropical regions. In warm climates, this development has not only led to an improvement in the quality of foods, with refrigerators keeping them fresh and wholesome until they are eaten; it has also made possible air-conditioning, which should be, and will eventually be, considered as important for the inhabitants of tropical regions as heating in winter is for those of temperate regions. A large increase in the demand for electricity will thus certainly result from the extension of air-conditioning, when the wealth of the population in question is high enough.

The Conventional Sources of Primary Energy

Until the recent past, the only important sources of primary energy were:

—*Waterfalls or Waterchutes*, essentially used for electric power generation,

—*Fossil Fuels* (coal, petroleum, natural gas), with general utilization for heating purposes or electric power generation, and special uses for which no substitution by electric power is practical, the most important of these being the use of coal, as coke, in blast furnaces and the use of gasoline as a power source in automobiles.

To these principal conventional sources of primary energy may be added a few others, although it does not seem likely that, in the near future, they will have more than local importance:

—*Energy from Ocean Tides:* A large pilot power station, using the exceptionally strong tides of the Mont Saint Michel Bay in France, has been in operation for the past few years, with an annual production of some 400 million kilowatt-hours. In the same region, with a very long dam, up to 50 times more energy could be produced, but it is not likely that this project will be carried out before the end of the century. In a few other places, as the Bay of Fundy, between Maine and New Brunswick, projects of similar magnitude are possible, but the total world production of electric power of tidal origin will remain relatively very small.

—*Energy from the Wind:* Small-scale experiments have shown that modern windmills would be nearly competitive for generating electricity in regions where the wind is regular and strong; but no significant development is to be expected in any predictable future. Although a large number of small aeolian pumps are used to provide water for irrigation in many places, winds will contribute little to the world supply of energy.

—*Geothermic Energy:* The rather high temperature of rocks at depths within reach of modern drilling makes the idea of using heat from inside the earth for power generation attractive. Until now, this has been practical only in a very few places in the world, in Italy, or New Zealand, where some kind of volcanic activity brings molten rocks not far from the surface. The only good experience is that of Lardarello in Tuscany, where a power station of several hundred megawatts has been operating for many years. This source of primary energy may become important, but certainly not before the end of the century.

—*Solar Energy:* Of course solar energy is, and always has been, of fundamental importance for mankind; all the energy in our food comes from it, and burning wood for heating or cooking is still essential for populations living outside cities. The possible development of this use of solar light, through photosynthesis in plants, will not be considered here; neither will the solar heat that evaporates water in salt-marshes (thousands of kilowatts per acre), nor that which warms greenhouses. The question here is: to what extent will solar energy be a substitute for fuels?

From this point of view, it may be noted that sunlight is already beginning to be used for heating water for private homes in North Africa and for cooking food in India and that the use of solar heat for desalting water, which is still only experimental, may become important in desert areas, but without producing a large amount of energy; a large production of electric power from solar energy is not in sight.

From this brief survey, it may be concluded that, within a century or so, the conventional sources of primary energy that may be of significant importance are hydroelectric power and fossil fuels. Considering the possible sites for new hydroelectric power stations throughout the world, some of which would be very large, it appears that their contribution to the satisfaction of the fast-increasing demand for energy will continuously decline, though they may be of considerable local importance.

Thus, if the conventional sources of primary energy alone were available, the future energy requirements of mankind would have to be satisfied essentially through an increase of the consumption of fossil fuels. It seems that the increased production of fossil fuels, mainly petroleum and natural gas, necessary to face this situation, could be met during the next few decades by the probable discovery of new oil fields. But it would lead, within a century or so, to the exhaustion of all the natural reserves of fossil fuels, and long before this complete exhaustion, a scarcity would appear, entailing an increased price for fuels and consequently for energy delivered to consumers. This would jeopardize the increase of energy consumption in the underdeveloped countries; the hope of raising the standard of living of the very large population of these countries to a level comparable to that current in advanced countries would be very dim.

Nuclear Energy

The discovery, some 30 years ago, of the nuclear fission by neutrons of uranium atoms and of the possibility of nuclear chain reactions has opened a new era for mankind by making available to man a practically inexhaustible new source of primary energy.

Fission is an explosion of a heavy atomic nucleus, usually caused by the absorption of a neutron, releasing a very large amount of energy and emitting or re-emitting, on an average, more than one neutron; this last feature makes possible the development of divergent nuclear chain reactions. A nuclear reactor is a system in which such divergent or self-sustained nuclear chain reactions are possible, with a corresponding release of energy.

Fission is not possible for all uranium atoms. Only the atoms of the rare isotope uranium-235 (only 0.7 percent in natural uranium) are "fissile"; the absorption of neutrons by atoms of the dominant isotope uranium-238 is followed by their transformation into atoms of a new element, plutonium, which does not exist in nature.

Nevertheless, divergent fission chain reactions may be obtained with natural or slightly enriched uranium, if neutrons are slowed down by a "moderator" between their emission by fission and their absorption by uranium, with fission of uranium-235 atoms or transformation of uranium-238 atoms into plutonium atoms, which happen to be fissile like those of uranium-235.

Because of these facts, the first models of nuclear reactors developed for industrial power production, whether operating with natural uranium or with enriched uranium, cannot utilize more than 1 percent of the initial natural uranium for generating energy. But one must remember that about

3 million times more heat is generated by the fission of any mass of uranium than by the combustion of the same mass of coal. In fact, nuclear power stations in which heat is generated by reactors with this low efficiency of uranium utilization are now competitive in most places with fuel-burning power stations, at least for units of more than 500 megawatts. In the advanced countries, where the use of such powerful units is possible, nuclear power stations already constitute an important fraction of all power stations under construction.

The rapid development of nuclear power stations would lead, within perhaps 25 years, to the exhaustion of all the rich deposits of uranium ore that may exist in the world. If low efficiency were to continue the price of uranium might become prohibitive. But it is already known that, by using the plutonium produced in the reactors of the present first generation as nuclear fuel in fast neutron reactors, operating without a moderator, more plutonium will be produced by conversion of uranium-238, than would be consumed by fission to generate energy. Such reactors, known as *breeder reactors*, will eventually make possible the generation of energy by fission of all the atoms contained in any quantity of natural uranium, either directly or after their conversion into plutonium atoms. The amount of energy generated with a given quantity of uranium will thus be much larger than at present, so that the price of uranium would increase more slowly with much less influence on the cost of the electric power produced. Eventually the rather expensive uranium that may be extracted from ordinary granite, which is a very poor but very abundant uranium ore, might be used without much increasing the price of the electric power produced. The corresponding reserves of uranium are so enormous that an annual energy consumption a hundred times larger than the present one could be satisfied for more than 10 million years.

The Problem of Pollution

The combustion of fossil fuels, a necessary process in the generation of energy, may entail very serious pollution of the atmosphere, depending on the quality of the fuel and the completeness of the combustion.

In the case of power production by fuel-burning central stations or of heating for industrial activities, the worst possible pollution derives from the sulfur contained as impurity in the fuel. The combustion of this sulfur produces toxic sulfur dioxide. Even the use of very high smokestacks to increase the dilution of combustion gases, will not be sufficient in the future, when the amount of fuel burned in populated areas will be much greater, unless the fuel consumed has a very small sulfur content such as in some coals or fuel oils. But it is practically impossible to desulfurize coal and difficult, that is, expensive, to desulfurize heavy fuel oil. For these, the rather costly purification of the combustion gases before they are dispersed in the atmosphere should be considered. On the other hand, desulfurization of natural gas is easy and even profitable, because of the value of the extracted sulfur.

The limitations on the sulfur content of fuels used for power production, which will have to be imposed by law for health protection, will undoubtedly increase the average cost of production of electric power produced by fuel-burning power stations. This will favor the development of nuclear power stations that do not pollute the atmosphere. This factor has already led to

the choice of nuclear power stations instead of fuel-burning stations in Switzerland and, recently, in New Jersey.

The other very serious cause of atmospheric pollution is the incomplete combustion of gasoline by automobile motors, especially when they are throttled down. Such incomplete combustion leaves a certain proportion of carbon monoxide, which is extremely toxic, in the exhaust gas. This means that there is already very serious pollution of the air in the heavy and slow traffic of large cities. A considerable diminution of the percentage of carbon monoxide in exhaust gases is technically possible without being very expensive. Here again, strict regulations will have to limit this percentage, as is already the case in California.

In automobiles, dangerous pollution of a different kind results from the extensive use of tetraethyl lead as an antiknock compound in high-octane gasoline. Every year, a hundred thousand tons or so of lead oxide, in the form of fine dust, are ejected into the atmosphere by automobile exhausts. It is in large cities that the consequences of this pollution may be most serious, with slow lead poisoning of the inhabitants a possibility. High-octane gasoline could be produced at slightly higher cost without the addition of tetraethyl lead; regulations could suppress this pollution by forbidding the use of lead compounds in gasoline. In the United States, according to a recent decision, such a regulation will be effective in 1975.

Radioactive Pollution

In normal operation, a nuclear power station produces practically no radioactive pollution of air or water. In case of a minor accident, any contaminated water could be held in special tanks before being released, after decay or purification according to the strict regulations universally in force, into the cooling river or sea. The air contaminated by fission products in such a contingency could be contained within an airtight reactor building and exhausted into the atmosphere through ordinary charcoal filters that retain the fine radioactive dust and radioiodine. Only radioactive inert gases, with no possible fallout, would contaminate the air exhausted through a high stack.

A major accident, with destruction of the reactor building—which is very unlikely—might mean radioactive contamination by fallout of the neighborhood of the power station. This would not imply an immediate danger for the inhabitants but might lead to evacuation for a more or less long time. Because of the difficulty, hazards, and cost of evacuation of a large population, nuclear power stations should not be situated in a densely populated area.

When large, fast neutron-breeder power stations, of a thousand megawatts or so, are in operation, a major accident would be more hazardous because of the large inventory of plutonium (a few tons) necessary in each of them. Because of the high radiotoxicity of plutonium, it would be wise to situate these powerful breeders in scarcely populated areas, with little or no population within a distance of some kilometers. Economical transmission of large electrical power, above 1,000 megawatts, at very high tensions, 750 or even 1,000 kilovolts, for long distances up to 1,000 kilometers has been already considered, and this should not prevent extensive development in the 1980s of nuclear power stations using fast neutron breeders.

The reprocessing of nuclear fuels after they have been used, necessary

to recover the residue of the initial fissile uranium and the plutonium that has been formed, leaves as waste a large amount of highly active fission products. As concentrated solutions, these are usually dumped into underground double-shell stainless-steel tanks. This is temporarily safe enough, but in the future, when nuclear energy is used extensively, such dumping will no longer be acceptable. Because the tanks are vulnerable, they might be destroyed in time of war or by sabotage, leading to very great radioactive pollution of underground water in a large area. To avoid these possibilities, quite safe methods of dumping have been devised; for instance, the fission products may be incorporated in a special glass, invulnerable to water, that can be very simply buried underground. Such methods, which are beginning to be used, are a little more expensive than the present one, and their general use would mean a small increase in the cost of electricity produced by nuclear power stations, which would not seriously impair their expanded use.

Thermal Pollution

The so-called thermal pollution of rivers by steam power stations, whether fuel-burning or nuclear, limits the amount of heat from condensers that may be dissipated in the river used for cooling them and consequently limits the total electric power that may be produced along a given river. This last limitation is significantly lower for most of the present types of nuclear power stations than for fuel-burning power stations, mainly because of their lower thermal efficiency (lower steam temperature). But for other types of nuclear reactors and for the future breeders, this difference does not exist.

Far from the sea and if no large rivers are available, cooling towers, in which heat is dissipated by water evaporation, may be used; it is a little more expensive but does not change the temperature of the river from which the small amount of water to be evaporated is drawn.

Controlled Fusion

The release of nuclear energy may result not only from the fission of heavy atomic nuclei but also from the *fusion* of light nuclei. Such fusion, essentially the thermonuclear fusion of four hydrogen atoms to form one helium atom, is the origin of the energy radiated by the sun and, in general, by the stars.

In the H- or thermonuclear bomb, energy is produced by the fusion of heavy hydrogen atoms initiated by the explosion of a fission bomb that raises the temperature of the thermonuclear explosive to a hundred million degrees. It is extremely difficult to "control" such a fusion process to obtain the more or less steady flow of heat necessary for industrial power production rather than a violent explosion. At present, the only possible technique appears to be the heating of heavy hydrogen at low pressure by an electric discharge, creating a very hot plasma (fully ionized gas) that might be contained away from any solid wall by a strong magnetic field. To avoid instabilities in such containment, the magnetic field must have a very special configuration. It has not yet been possible to contain a hydrogen plasma (or any plasma) for sufficient time to obtain self-sustained thermonuclear fusion, even in the most favorable case of a mixture of deuterium and tritium. Nevertheless, it seems that, within less than ten years, demonstration of the feasibility of controlled fusion may result from the operation of large experimental devices now under construction or from still bigger ones of the following "generation." When the feasibility of controlled fusion is well established, it may take only 20 years more to develop a fusion reactor. It is likely that the heat generated by the first large fusion reactors will be several times more expensive than the cost of the heat generated by a fission reactor, in spite of the fact that the cost of the fusion nuclear "fuel" (deuterium from heavy water and lithium, from which neutrons regenerate tritium) will be negligible. It may take more decades to develop a competitive fusion reactor and to be able to use it especially if its minimum economical operating power is very large.

The main advantage of a fusion reactor in comparison with a fission reactor is that it would not produce large amounts of long-lived radioactive waste. Controlled fusion may thus be of great importance for mankind, but we should not expect to be able to use it on a large scale before the middle of the next century.

General Conclusion

Because the production of electricity by nuclear power stations is already economically advantageous, at least in certain regions of the world, large development of the use of nuclear energy may be expected in the near future. The extensive use of nuclear energy will help to avoid a rapid increase of atmospheric pollution.

In the somewhat more distant future, the possibility of producing very large amounts of cheap electrical energy anywhere in the world may create new conditions of development, such as the agro-industrial complexes conceived by the Oak Ridge team.

In the long run, without nuclear energy there will undoubtedly be a scarcity of fossil fuels, which would increase the price of energy, limiting the amelioration of the average standard of living in underdeveloped countries, and perhaps even start a certain decline in the material condition of mankind.

The fundamental importance of nuclear energy is that it may prevent such a decline, not only in the next century but for millions of years to come.

ANTHROPOLOGY, SOCIOLOGY AND PSYCHOLOGY

Chairman, Margaret Mead

Cochairmen, Gardner Murphy, Hans Speier

MEAD: I got a new insight from reading Gardner Murphy's prepared paper, and *that* possibly is going to distinguish the kind of contributions that the different sciences or different disciplines make to their whole field: there is a difference between the people whose scientific materials are precious and those whose scientific materials are extraordinarily cheap and virtually boundless; a difference between those who, at least until very recently thought their materials were boundless—such as oxygen—and who deal with a great number of reversible processes in many cases, and those disciplines whose materials are precious, rare, or irreplaceable, or who are observing irreversible and possibly unrepeatable processes.

One of the things that is happening in our whole attitude toward this planet at present is that we are beginning to think of it as small, isolated, and if not unique in actuality, quite unique in particularity, because chances of our working with other species in outer space within our lifetime seem rather small at the moment. And we are beginning to think of how many irreplaceable materials there are in the many irreplaceable processes.

If we once lose people with special sorts of experience and education, we are not likely to find them again, certainly not in our lifetime and possibly not at all. So that one of the differences between treating human beings "as guinea pigs" (one of the accusations frequently made against the social scientists), or not, is not so much that we treat them as animals, because I don't think anybody does treat them as animals, but that we treat them as if, in a sense, we have an inexhaustible supply.

Anthropology is one of the human sciences that deals *par excellence* with rare and precious materials, with vanishing people, rare fossils, bits of prehistoric man—types that survive with only a very few fossils in their midst.

And this gives us, perhaps, a different attitude, one that can be more easily transferred to our own present ecological crisis, in which we feel that our situation is unique, the state of the planet is unique, and the steps we have to take are unique, historical steps related to a particular moment.

This panel differs a little from the others at this Conference, because, although we have discussed fragmentation several times, much of the fragmentation we have been discussing has been within a science, but nevertheless one whose relationships to other sciences at least were historically regular.

We represent three branches and, if we include education, four. I do not like to think of education as separate from the other human behavioral sciences. It should never have been separated, and has been only by perverse historical circumstances perpetuated by perverse human beings. If we had not been so separated, if we had been working with the whole body of materials that are appropriate for each of these three disciplines, we might have a great deal

more to say than we have to say today. We are the outstanding charge of irregular and inappropriate fragmentation.

We now have batches of people who are utterly illiterate in other branches of their subject: Sociologists will publish an article without one reference to an anthropologist—and anthropologists do the same, and psychologists.

Given the fact of this fragmentation, we have practitioners with different styles of behavior and different bodies of material on which they draw. In my formal paper I attempted to emphasize the point that anthropologists have historically dealt with wholes, starting with the whole of mankind, his history, his language, his past and his present, including the development of his body as well as of his mind and culture.

Because we have had to narrow our sights to do particular work, we have always dealt with small, manageable wholes. We have preferred very small, preliterate societies because it was possible to control the material. Language is a preliterate material; the linguist was the first person who ever put language in writing, and he has very good control over his material in these circumstances.

We can be compared somewhat to those paleobiologists and ethologists who deal with species on very small islands, where they command the entire flora and fauna, and who work within bounded systems that can be completely known to the extent that we know what we do not know. This is, I think, one of the ways in which we perhaps differ from the sciences that attempt to take some aspect of society, like economics, and study it without a systematic inclusion of the unknown.

Because we have worked with small, bounded wholes that can be encompassed within the study of living human beings, we are able to treat wholes in terms of what is known and what is not known. This is rather easy to extrapolate to the planet, or the solar system, or whatever size universe the scientific community is focused on. One can move from a small, known society on an island to the planet, to the solar system without a change of posture, and rather easily.

The other thing we realize very accurately is that we have lately moved from the use of human beings as complex instruments for the study of human behavior. We have recognized that the only instrument we had that was worth anything until very recently was the whole human being, and by having the same human being study several cultures, if possible, and integrate the material in his head—and I think we can still agree that the human brain is the best computer that we know anything about—we have been able to arrive at the ordering of materials that we have to date.

At the same time in history, we were no longer able to find students who could make this kind of integration because they had grown up in a world that is fragmented and so multiple that they did not have the kind of experience of one culture that makes it possible to learn another.

We now have methods of recording and analysis that can supplement these orders of human intuition. Heinz von Foerster has been scolding me about this point, because he says the young people do want to integrate these things. This is true. I am not saying they do not. I think we have a whole group of students that would like to look at everything at once.

What I *was* saying is that the older type of anthropologist is disappearing and we now have, instead, young people who can use the new methods of reporting and analysis and computerizing that will replace, for our more

complex world, what the old forms of anthropologists were able to do in their heads. We have whole groups of people who are working very hard to develop units appropriate for the analysis of complex wholes that can be handled mathematically and with computers.

There is a new science of kinesics, which deals with culturally patterned human behavior, with the unit called the kine.

There are the minor subsciences of anthropology called proxemics, which deal with the interrelations of human beings in space with the proxeme as the unit.

There is the use of videotape and the development of the action, by which we can analyze very complex videotape records of behavior in the relationship of human beings and the other objects in space. These are all units that relate to situationally placed, historically determined human behavior, and that can be dealt with with the sort of materials that we work with. These always are unrepeatable events; no event in the study of culture that is simple enough to repeat is valuable enough to study, on the whole, but if we can record it satisfactorily, then it can be studied over and over again by new theories, new forms of analysis, et cetera.

So I think the ways in which anthropology is going to be able to contribute to our common enterprise is its habit of dealing with wholes, and it is a very significant contribution when compared with working with those social scientists who have necessarily had to limit themselves to one kind of data or another within complex societies.

But this habit of dealing with wholes seen as the behavior of living peoples, and the tremendous interest today in the development of minute or micro-methods of analysis that are appropriate for the computer will mean that as our material escapes the grasp of single human minds, the computer can substitute for a large number of these activities.

I think it even possible that adequate methods of retrieval will mean that individual human minds can deal with materials from many different disciplines as well as from many different observations; not only won't they have to go through all the steps, but in many cases they won't have to go through the same masses of data that used to be necessary, or sit in the same room for 12 years before they can talk to each other.

In both cases, simulation models of wholes into which we can feed material that has been adequately analyzed will replace the old forms of interdisciplinary work, which primarily consisted of catching a group of well-disposed social scientists and keeping them in one room long enough so that they could learn to talk to each other, which is a slightly crude method.

We will still need some of that talk, which is what we are doing here, catching a group of well-disposed people from many countries. We are not here using any materials that have been reduced to a form that could be used by everybody here, and I think this is something that we can hope for.

MURPHY: I would like to underscore a few of the things that Dr. Mead has said.

If one asks what can be expected from psychology as a social science and wonders why some of the results that we would expect are not forthcoming, we must remember that psychology came into existence less than a century ago.

In the effort to create a new biological science using experimental methods, essentially those of experimental physiology, I would say the environment is one of the first things a psychologist would have to consider. If, however, you visit a modern laboratory in which a room has been established for the study of the environment, you will find beautiful studies of air currents, temperatures, moisture, and light and shadow, and possibly something as complex as the perception of movement. But anything like the culture within which the professors and their subjects are operating would be automatically ruled out as a disturbing variable.

The rules of the game are established in such a way as to make broader environmental studies increasingly difficult because of that urge toward specialization that Dr. Mead has pinpointed.

I think we may say that our prime problem today is to focus on those studies of psychology that enable the experimental psychologist to do what he can do and at the same time find himself in a companionship of kindred sciences that take a larger course, notably cultural anthropology, which is disciplined to conceive of larger processes within which the specific psychology of the individual has membership character.

With this point of view you automatically include as part of your problem that which has previously been excluded as irrelevant. As Margaret Mead suggested, the Yale sophomore coming for a psychological participation experiment is supposed to park his culture outside. Not only the sophomore, however, but very often those who designed the experiments carry out the same operation. Within this setting, what can we do? We have to catch them young. When we do catch them young, we find this holistic, this Gestalt tissue, a broadly human preoccupation that has not yet been stifled.

I encounter them at all levels, hungry for a kind of bread that is not allowed, literally driving their insights to a period after their doctorate, as if they could possibly preserve this first broad flush of excitement about humanity until after they have been subjected to the nose-grinding process of undergraduate specialization and four or five more years of graduate study. During these years, the status, all kinds of social reinforcement, economic ones as well as those of prestige, are determined largely by this skill in avoiding the general, not getting too philosophical.

I think the issue is not hopeless if one realizes that the answer is to encourage whatever we can in the way of humanness when it first appears in the young. I am speaking of all those I see first exposed to psychology, sometimes even freshmen, certainly very commonly sophomores, and very much so juniors and seniors. They are preoccupied with something that will both be theoretically exciting and likewise have some relation to the ghastly situation in which the human race finds itself.

Is it not a little preposterous, for example, that one finds, as a superspecialty later in psychology, the question of whether it is too late already, given our weaponry, to expect to make some contribution that will be relevant? For example, the elementary problems of vertical communication that students begin to raise relatively early: Why is it that all peace research that has been done, with all the able people devoting themselves to the psychology of international relations and the threat of war, has not developed a channel that would enable us to make possible vertical communication with those in positions of political responsibility?

Those young people begin to discover that is not a part of scientific psychology. In fact, ways are usually found, relatively early, to deflect their enormously intense, passionate craving to participate in a psychology that will make a difference, in which a conference like this, or any serious con-

ference of professionals, will work toward communication that will be evaluated in research terms, so that one learns what is effective and what is relatively ineffective, so that the whole professional wisdom of the social sciences becomes a matter of creating a magnificent system of broad human understanding and takes on a form, a character, a structure that will make possible further continuation of humanity on this planet.

These are the kinds of questions, both theoretical and practical, that young people want to have partially solved, and in the further solution of which they hope to have a part.

It will take, however, an enormously hard, long pull. Psychology as it stands today is not ready to do much. It is ready to contribute, along with the biological sciences, toward a fuller understanding of the human central nervous system by chemical processes, et cetera, which, of course, have their continued pertinence to social issues.

But to see the ecological issues broadly will take a long period of reeducation of the psychological profession, particularly of the eager students who, if encouraged, will grow into the men and women who are concerned with that type of applied research, research on which the human future will depend.

MEAD: And now, Dr. Derek de Solla Price, and then Dr. Emily H. Mudd.

THE EXPANSION OF SCIENTIFIC KNOWLEDGE

Derek J. de Solla Price

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Science is explosively filling the world at an exponential rate faster than that of any population explosion. It has been doing this for the last few centuries, so that at all times past we could look around and see that almost everything known in science had been discovered only recently. During the centuries, more and more countries erupted into the scientific age. Now, something is suddenly new, and we have witnessed for the last decade a steady and mounting deceleration of the largest and most developed countries.

The "overdeveloped" countries, the U.S., the U.S.S.R., and perhaps the U.K. and a few other nations, are suffering from a sort of ecological disaster of information pressure. There is an overpopulation of scientists and scientific papers manifested in a flood of publications, of abstract and index journals, and of bibliographies of indexes *ad infinitum*. We witness also the cybernetic damping effects caused by lack of national funds, lack of motivation toward the hard and basic sciences, and, to crown it all, an onset of machine murder, neo-Luddite rumblings, and a craving of the young to escape by way of mysticism, drugs, and contemplation.

Already the general effect of this onset of a ceiling to efforts has gone far, much farther than the more recent recession in U.S. Federal research and development funding would suggest. My guess is that both the U.S.A. and the U.S.S.R. have now only about half the scientific stature they would have had in the absence of saturation.

The result of this overdevelopment and scientific crowding is that the world is not filling up evenly with science; the little countries are now growing more rapidly. Though the big powers still grow absolutely, they are declining relatively, and the decline becomes faster each year. It is rather like the vote in the United Nations, where the crowd of small nations may now have an absolute majority that a single great power cannot overcome.

Not yet visible, but inevitably approaching, is the fact that before we are even used to the blessings of a world where scholarly and diplomatic discourse can get along with very few big languages, those biggest languages must now decline. English, which had constituted much more than half the world's philosophical and technical language, is now slipping back by about one percent per annum as the little languages rise. We must expect Japanese to mount in importance as that nation's technology approaches and, perhaps, will soon rival that of the U.S.S.R. and the U.S. not long thereafter.

We must recognize that science is a world task, growing on a world scale and less and less amenable to organization by the superpowers. Perhaps the first moral is that the smaller nations should make even more efforts to integrate their university science with their primary and secondary education by moving away from English and Russian and toward getting decent home-grown books in their national languages. We had taken an opposite line, against nationalism in science, but it may now be good tactics to reverse course.

One need not worry too much about the difficulty of communication. Scholars do not read much in any case, and virtually nothing in foreign languages; to be more precise, each language looks at foreign literatures through dark glasses that let through only about one-tenth of what is there; the smaller the language, surprisingly enough, the darker the glasses. The probable reason for this is that it is vital for scientists to feel themselves part of a highly interacting scientific community that can be evaluated and possesses the autonomy and competence to facilitate its work by providing reasonable conditions and checks.

The most oppressive influence of the science that continues to grow on the world scale is not the unevenness of that growth from one country to the next but the stupendously continuing rate of accretion. We have almost exhausted our resources by straining so that all might be published and all indexed, and now it begins to appear that this was not quite the right line to take. By having a hierarchy of merit among journals and by having editors and referees sit in conscientious judgment on each paper, we thought we had improved quality. In fact, the gatekeepers only delay and shift publication; they do not prevent the flood. By supporting journals that could not stand a cruel marketplace we maintained valuable forums—but for what?

It seems we might have done better to take immediately the line that is being forced on us. Any journal that can die in the marketplace should be encouraged to fold up forthwith: any paper that can be aborted or strangled should not be set in type. Perhaps we should take another look at the vigorous and productive Information Exchange Groups that were suppressed by the scientific establishment because they spelled danger to the canonical procedure.

Let it be realized at last that *publication is not a duty consequent on time and money spent; it is not a right consequent on a mere desire to speak: it is a privilege consequent on there being some person who really wants to listen.* We write to communicate with real people, not with a faceless archive. Most of the so-called information crisis is caused by technologists wanting to read something different from what the scientist writes for his own purposes of scholarship.

Part of the reason we might be pushed to this realization is because we have now developed a considerable disillusionment with the potential of the computer in the particular capacity in indexing and setting in retrievable order the science that is embedded in the gigantic literature of the archive and the research front. Order exists, but that which is in papers is not quite an ethereal phlogistonlike fluid of "information" that may be stored and retrieved. It seems that a large graininess is built into indexing methods of all conceivable varieties, and in the long run the computer does not help fundamentally.

We have only two radically new and efficient tools. One is the citation index, which revolutionizes the research front and enables us to move forward in time instead of backward when we search bibliographically. The other is the taxonomically indexed data bank, such as can now be managed in chemical compounds and nuclear constants. It is about time that papers containing such data be fed straight to a central data bank rather than via a journal.

Though we can do fabulous things, what we cannot do is provide a direct substitute for the ingenious packing down of knowledge that goes by the name of scholarship. It is a most clever process: How else could we leapfrog a graduate student right up to the research front when that front is, by co-

operative effort, running much faster than any one established individual scientist can run?

Perhaps it is not commonly recognized that it is in this matter of the existence of tight-structured research fronts that science sets itself apart from all other sorts of scholarship. The difference between science and humanistic scholarship is not one so much of methodology or concern. It is in the sociology of interaction of its workers. If scientific communication is wounded, science may die.

Lastly, a word about the use of this knowledge, i.e., the reason we need it. Scientific learning grows, in the best model we have, like a giant jigsaw puzzle in the process of cooperative solving by a team of players.* Each player strives to find and add pieces; sometimes one area is hot, sometimes another. One cannot pick a piece and decide that this must be fitted next; it may or may not have its natural "turn" at that juncture. In the knowledge industry, we all play against Nature, and she acts as if there is, in truth, only this one world lying there waiting for its pattern to be discovered. Technology is not like knowledge; it is things and processes that society wants an knows how to make. Each nation and culture can choose and buy the technology it wishes to have and reject what it wishes—within reason. Science one must take or leave. It happens, however, that to work with modern highly scientific technology one needs a population educated to some degree—often the highest—in matters scientific.

To put it bluntly, *science is the only means we have for investing in future technologies.* By attempting to train for the technologies perceived today we can get only products that are and must remain a decade stale. Moreover, if we demand "relevance" to needs and wishes, to techniques and knowledges that are visible and aware today, we are also in jeopardy of an investment in only the present. Science and technology move too fast for that, and even the most developed nations do not have enough control of the world to declare a moratorium. We must all plan for this future by a certain return to faith in the virtuous necessity of basic scientific knowledge and full education to all the research fronts, no matter what their apparent relevance—or lack of it.

* * *

EMILY MUDD: We have been hearing, here, of the very holistic qualities of science and of the various disciplines, and I think that in the paper that follows, I will try to talk a bit about the human, and the very personal, side of some of the problems that have been indicated through this conference. I don't think that there has been a speaker who has not, one way or another, headed into some of the great problems of the world, of which the population crisis is admittedly one, and I have been interested that no matter what the scientific background, so many speakers have mentioned this. It seems to me that the problem of population control, or, in other words, of family planning, is, in a certain sense, certainly holistic, as Margaret Mead and others have said. But we must take into account the cultural background of each man and each woman involved in this world of ours if we are going to come to grips with this very intense human problem of our world.

* Oddly enough, there seems to be an absence of research on the psychology of jigsaw-puzzle solving and no time/motion studies of it.

YOUTH AND POPULATION *

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Education is an important element in the struggle for human rights. It is the means to help our children and people rediscover their identity and thereby increase self-respect. Education is our passport to the future, for tomorrow belongs to the people who prepare for it today.

—*Malcolm X*

Nonhuman species, from unicellular forms to animal herds with instinctive socialized behavior, have been controlled in size by their available environmental resources. So far only the human species has been able to manipulate its environment. In the last ten centuries, accommodation has been made to include 3½ billion people on our planet. The demographers tell us that if the present rates continue, this number will double in 30 short years and become 7 billions before our eyes—and then to standing room only. What, then, of our already overtaxed resources? Common intelligence concedes that the youth of the world will have a determinative function in handling this problem. In the last analysis, population control is an intensely human problem.

We must now ask what will influence youth in relation to the future? How real is this threat of overpopulation to warm-blooded and healthily sexed young men and women? What can substitute for the miracle of a wanted child nurtured by one's own body? What brings man closer to immortality than the experience of reproducing himself? And to these instinctive forces must be added the cultural heritage of hundreds of generations throughout the world, in which survival for parents was dependent on support by their children, generations in which the religions of the world have blessed the advent of each new life as it arrived.

Medical miracles have reduced the death rate and gladdened the lives of millions, but the resulting population explosion has gradually and insistently saddened the outlook of mothers and fathers throughout those areas in the world and in our United States where living conditions do not produce, and show no possibility of producing, situations in which numbers of children can be nurtured to healthy physical and emotional development, with a future worth living for. It has been shown conclusively that a succession of births in any substandard family increases greatly the odds against achieving adequate health, education, or job potential for every child in this family. "Children from smaller families can take better advantage of learning situations in and out of school. School dropout rates in turn are lower among such children and they have more years of formal schooling. Needless to say, greater education is associated with higher occupational status, higher income, and

* Based in part on a paper presented at the Second Spiritual Summit Conference. Geneva, Switzerland, March 31–April 4, 1970.

lower unemployment." [a] In addition, medical reports correlate repeated pregnancy with premature births, loss of the mother's health, despondency and frustration of the father, and even permanent mental and physical retardation of those children who are subjected to undernourishment and malnutrition. Thus, the human problem is brought home and into the hearts of the individual parent and, perhaps because of the nature of things, especially to the hearts of women. The belief that some Divine Providence will take care of all little ones has become increasingly difficult for the mothers of the world to accept and to take comfort in.

I believe almost every woman basically wants to be a mother. But after a first and a second positive experience, if the next and the next and the next unplanned baby is born into squalid conditions, is undernourished, and has no reasonable future, new thoughts and questions force themselves on the less privileged mother as well as on women with higher education and income. A life with reasonable quality and satisfactions is the ideal of every mother for her child. In our contemporary world, competition for food, education, health, space, and work in reality leads to unachievable goals for many mothers of children throughout the globe. Will these conditions, if continued and worsened, have an impact on the individual mother and father? How will the religious, educational, legal, and governmental institutions respond to these realities? Who will help the individual father and mother to understand the changes in world conditions in the last half century and to handle the conflicting values occasioned by these changes?

An illustration from our own country can, I am sure, be duplicated in other cultures. Following World War I and II, educated young women in the United States achieved status and community and family approval as they presented three or four or more healthy progeny to their world. Less privileged women became subject to disapproval from the same sources when they and their five to fifteen babies became community responsibilities. Thus emphasis on a differential birth rate inculcated hostility and resentment, "No one," it was said, "has the right to tell anyone else how many children they can or should have. This is up to the individual." "One of the joys that cost nothing and that no one could take away from the poor was their sexual activity and their babies."

During this period, some methods of child spacing were available privately to the privileged and were condemned by certain religious and other groups. There were no efforts to publicize the advantages of child spacing on any large scale, nor were contraceptive materials available to millions of women in poverty areas.

During the same period, scientific advances in preserving life so changed the former balances of population that the world leaders and governments have been faced with dealing with an overcrowding never known before. The unwelcome realization that the birth rate is, indeed, no longer a private affair cannot be disregarded. Reputable sources, including some governments, have encouraged research into new, safe, easily used, and inexpensive methods of preventing pregnancy. Men and women—first the privileged and, much more recently, the less privileged—have become aware of the possibility of reducing the number of their children to those wanted and for whom reasonable op-

[a] The Effect of Parenthood on Marriage, by Emily H. Mudd. World Academy of Art and Science News Letter, No. 8/9, December, 1968–January, 1969.

portunity in life could be expected. Emphasis is still on the individual choice of the parents. With one outstanding exception in an official sense, most of the great world religions have countenanced these new approaches, have accepted the dissemination of information, and in some instances have publicized their approval of such approaches.

Certain governments, both with and without the aid of specially equipped internationally oriented organizations, have conducted educational and service programs among their less privileged citizens. These programs have resulted in a definite decrease in their rate of population growth. Notable among these nations are South Korea, Taiwan, and Singapore, of the Federation of Malaysia. In some other countries there have been efforts less organized by government, and based primarily on humanitarian reasons, that have achieved a perceptible decrease in the percentage of population growth. Among these, Japan is outstanding. In still other nations, efforts to stabilize population have failed or have not been looked on with favor.

That women in the United States in 1970 do want to space their babies is reflected in reports informing us that nearly half the women of childbearing age—more than 15 million—are using contraceptives in spite of a small percent of medical hazard. We are told that, of the babies born in the past decade, 20 percent—about 600,000 births in 1969—were unwanted and that more than 5 million indigent women did not have access to means of child spacing no matter how much they desired this.[b] In addition, it is said that one-eighth to one-quarter of all pregnancies (between one half million and 1 million) end in illegal abortion yearly in the United States. I have had the privilege of talking individually with a variety of underprivileged mothers. These were predominantly young and living on Government subsidies. Many had three or four infants before their 25th birthday, and 93 out of 100 interviewed had had sex relations between the ages of 12 and 23 while still single. When I asked what they considered their ideal number of children, the majority said two or three, a few said more than three, and none out of 100 wished less than two, reports very similar to those of their more privileged sisters.[c] A well-known gynecologist-obstetrician makes this statement: "Based on my experience in a large private practice in the last ten to fifteen years, there has been a definite change in the ideals of women as regards family size. After World War II, many of my patients expressed the desire to have four children and proceeded to do so. In the last ten years, more and more of my patients state that they would like to have only two or three children, and they seem sufficiently motivated in this aim that they are succeeding in so limiting their family size.[d] Young women, with the knowledge and approval of their men, are planning to use an assortment of family-planning methods, including early therapeutic abortion for medical reasons and tubal ligation after several babies. Choice and decision was their prerogative after reliable information and access to suitable methods were made available. The emotional and practical importance for each woman of having an opportunity to personalize her

[b] Based on testimony of William H. Draper, Jr., before the Monopoly Subcommittee on the Small Business Committee, Washington, D. C., March 3, 1970.

[c] Psychosexual Response and Attitudes Toward Family Planning Among One Hundred Pregnant Women, Augusto W. Chang-Silva, M.D., Emily H. Mudd, M.S.W., Ph.D., Sc.D., and Celso-Ramon Garcia, M.D., Journal of Obstetrics and Gynecology, *37:* 289–296, February, 1971.

[d] Alan Rubin, M.D., Philadelphia, Pa., February 12, 1970.

knowledge concerning the use of family-planning methods has been made abundantly clear in many reports.

The moot question that all religions, institutions, and governments have now to face is hard upon us. If information and materials can be made available to each and every man and woman, with the present rate of failure of method, the inadequacy of medical procedure, the impulsiveness of many users, and the lack of individual educational opportunity, will the present approaches to family planning in the United States and elsewhere accomplish the results considered necessary—a two-child family—within the time limits still available to us? Approaches varying from persuasion and governmental recognition and rewards to social legislation and the possibility of legal regulations are being discussed. One prominent Government official recommended at a conference on environments that families stop with two children only. He also said the Government might have to offer "disincentives" to discourage parents from starting big families. Mass communication through radio, television, periodicals, and the daily press, with national and international distribution, presents figures and dire predictions of future deterioration and possible extinction if as many babies as were born in 1969 continue to arrive. They also present firsthand documents of reputable individuals who countenance early abortion, men and women who submit voluntarily to sterilization and undertake adoption instead of procreation. An outstanding woman writer puts it this way: "Perhaps the real turn in the road will come—and I predict it is coming soon—when more than two children to a family will seem bad taste, like wearing mink in a starving village. . . . Such an event could alter, for both men and women, the whole picture of American life." [e]

Young people of all economic conditions wish to have and are having a definite role in their own destiny. They are aware of the limitations to their future caused by the unsolved dilemmas of our world—of which overpopulation is basic. They can say to us of an older generation, "You have never been young in the world I am young in, and you never can be." [f] We in turn must acknowledge an unprecedented generation gap before communication can be effective. This break between generations is new, planetary, and universal.

Individual young women the world over are beginning to understand in their hearts and to recognize through their intelligence that there are many assets for the present and future of their babies in having fewer brothers and sisters. There are also assets in this for their own lives and their husbands'. It seems reasonable to predict that because of this understanding and recognition these young women and their husbands will desire the surest and safest means of not having more than one or two living children. To effect such results without coercive controls, education, religion, the social and biological sciences, law, and government can have a vital part. Their representatives can lessen perceptibly the conflicts of young men and, especially, of young women in dealing with the as yet unknown and unexperienced changes in values and behavior demanded by this new concept of family size for the world of the immediate future. They can cooperate in discovering surer, safer, and more acceptable means of family planning. They can exchange views and initiate

[e] We've Never Asked a Woman Before, by Catherine Drinker Bowen, The Atlantic, March, 1970, pp. 82–86.

[f] Culture and Commitment, by Margaret Mead, Doubleday, N.Y., 1970.

constructive dialogue to explore what part in this unavoidable dilemma the recognized institutions and the leaders of the world, together with the young people, wish to take.

We are all, whether we want it or not, part of this problem. Let us see to it that we are part of a constructive answer.

* * *

MEAD: Dr. Harold T. Christensen is next.

CULTURAL RELATIVISM AND PREMARITAL SEX NORMS: RESEARCH BASES FOR MORAL DECISION

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This paper focuses on premarital sex. It attempts to build an empirically based theory explaining social change and describing cause-and-effect relationships as background for rational decision making in a scientific age. Although at this stage of development the analysis is exploratory and its data are somewhat limited, it can illustrate how the sociologist works in applying himself to problems of this sort and also point to the kinds of research needed for clarifying and perhaps eventually resolving the issues.

By *cultural relativism* we mean that things are relative through time and space according to their cultural settings. It has been commonplace among social scientists to observe variations in belief and behavior. To this we add the relativity of consequences. By *norms* we refer to the mores, or established moral standards, of a society. These are the prescriptions and proscriptions that the group considers of great importance to its welfare and so surrounds these norms with positive and negative sanctions—rewards and penalties. When norms become internalized within the personalities of group members they are called *values*. Values are the individual counterparts of group norms.

By *moral decision* we refer to choices based on criteria that are deemed important; that is, on values and norms. Although morality is sometimes used in the narrower sense of a "good" or "right" assumed to be intrinsic in the nature of things, it is applied here to connote any system of propriety, whether its standards are thought to emanate from divine or human sources. Thus, in the context of this analysis, moral decision making can be thought of in relativistic terms.

Science, which by definition is value-free, cannot in and of itself make a moral decision. But, by laying bare the varying consequences attached to alternative lines of action, it can provide the needed elements or *research bases* for rational choices aimed at maximizing the net positive effects. Our present task is to apply these concepts to the phenomenon of premarital sex.

NEW FREEDOMS AND CONFUSIONS

Social scientists know of no society, past or present, where sexual behavior has been completely unregulated. The quality of imposed restrictions has varied greatly, and does now, but always there have been restrictions; never has there been absolute sexual promiscuity as a standard practice. Another way of saying this is that all known societies have some form of marriage designed to exert some degree of control over adult sexual relationships.

There has developed in the Western world a tradition known as the Judeo-Christian sex code, which has for many centuries reinforced marriage as a

regulator of sex. According to this code, sex is for marriage only, and even there it exists chiefly for purposes of procreation. Strict chastity has been promoted as the norm, backed up by the belief that this is an external principle commanded by deity.

But with the development f science and technology, this tradition has been exposed to severe challenge and is now losing ground. In his search for facts, man has become less willing to rely on faith alone. Furthermore, with greater understanding of the processes of and advancements in contraceptive and medical technology, many of the earlier risks have been greatly reduced—risks of detection, infection, and conception. On top of this, there have been court decisions that have legalized all but the hardest of hard-core pornography, and recent developments in the mass media mean that almost everyone is exposed to an almost constant barrage of erotic stimulation. Today the lid is off: There are topless, and even bottomless, entertainers; there is complete nudity in the legitimate theater; there are underground newspapers and magazine, book, and motion picture portrayals that leave almost nothing to the imagination; there are "filthy-speech movements," "free-sex movements," "group-marriage movements," and the like.

The question of whether premarital coitus has increased significantly in America during recent years is in some dispute, because of a lack of relevant data. That attitudes have liberalized everyone is agreed, but practice may be another matter. The earlier Kinsey data suggested a large jump in nonvirginity during the 1920s and then not much change during the 1930s and 1940s. Influenced by this finding, Ira L. Reiss and others have concluded that there has probably been no significant recent increase in premarital coitus. But the Kinsey data are too old to throw light on the 1950s and the 1960s, and no other data suitable for a trend analysis have been reported for these decades. Nevertheless, some of my own data are relevant here.[a] As part of a larger study, students in a midwestern university were sampled, first in 1958 and again in 1968 (Christina F. Gregg gathered and analyzed the 1968 data); they were asked to indicate their personal approval of and experience with premarital coitus:

		Males	*Females*
Percent approving:	1958	46.7	17.4
	1968	55.4	37.7
Percent experiencing:	1958	50.7	20.7
	1968	50.2	34.3

The results give rather clear indication of three things: (1) approval went up for both sexes but the increase was proportionately greater for females, which means a trend toward intersex convergence; (2) coital experience remained at about 50 per cent for males but moved from nearly 21 to more than 34 per cent for females, which again spells out an intersex convergence; and (3) attitudes liberalized in greater magnitude than did behavior, so that, for both sexes, more experienced premarital coitus than approved of it in 1958, while the reverse was true just one decade later.

[a] For a more complete reporting, see Harold T. Christensen and Christina F. Gregg, "Changing Sex Norms in America and Scandinavia," *Journal of Marriage and the Family*, 32 (November, 1970).

Whether this new freedom over sex is a long-term trend or but a temporary pendulum phenomenon is not clear from available evidence. Only time will tell. But there can be no questioning that it is a radical departure from the past—at least the immediate past in this country—and that it is resulting in considerable confusion, tension, and conflict. So rapid and far-reaching are the changes that the movement is often dubbed "The Sexual Revolution" and its outcome "The New Morality."

A revolution, very likely; but a new morality, not yet! It takes more than freedom to constitute a morality system. The Judeo-Christian sex code has been yielding ground, but, in many circles at least, there have not developed new standards to take its place. Although beliefs and practices are in radical transition, discussions concerning what is and what ought to be remain largely at the level of polemics. Science has had a great deal to do with creating the present environment of freedom and confusion within the sexual arena. It also has a responsibility—and offers the best hope, perhaps—for lessening the confusion and easing the decision-making process.

Deriving Values from Research

It is not within the reach of science to decide on questions of right or wrong in any ultimate sense. By definition, science must confine its work to measurable data and let its generalizations spring from these data alone, avoiding value judgments. But this is not to say that the scientist cannot *contribute* to the development of a morality system. By clarifying a problem in terms of its elements, the processes at work, and the varying effects found to be related to alternative lines of action, the scientist certainly can add something. He can, that is, providing the primary underlying assumptions give credence to the scientific method—which is generally the case today. Choosing to rely on science is itself a value judgment, but once this decision has been made, the way is open for objective testings of cause-and-effect relationships, and the empirically derived knowledge that results can then be used as the raw material for one type of morality system. It is in this special sense that I refer to the possibility of values' being derived from research.

Alternative Value Positions

The positions that people take concerning questions of sexual morality are many and varied, differing primarily because of the nature of their basic life-organizing assumptions. If they assume the existence of transcendental authority, their position is likely to be absolutistic; if they think in phenomenological terms, relativistic; if the pleasure principle is given priority, hedonistic.

Here are brief characteristics of these three basic value types: (1) The *absolutistic position* is that the ultimate sources of truth and right transcend the reaches of man, that there are unchanging guidelines emanating from deity and intrinsic in the nature of things. This is a "morality of commandment," and its followers typically do not feel moved to test or prove anything, only to believe and obey. In its purest form it has been ascetic, encouraging self-denial and expecting sexual abstinence outside of marriage for both sexes and self-

control even within marriage, acknowledging only the need for reproduction. This has been the traditional Judeo-Christian code mentioned earlier. (2) The *relativistic position* is that human behavior must be seen within the context of cause-and-effect sequences, that acts may be wise or foolish in terms of their positive or negative results but not necessarily "right" or "wrong" in any ultimate sense. This is a "morality of consequences." Its followers are interested in rational decision making, relying chiefly on understanding the relative effects of acts according to time, place, and circumstances. It has been called "situation ethics," but its full development will require more than supporting arguments submitted up to this point. It will require the careful and somewhat detailed testings of science. (3) The *hedonistic position* is that personal enjoyment is its own justification, that what is pleasurable is good, regardless of religious pronouncements or social norms and (in its most extreme form) regardless of consequences other than the pleasure achieved. This is a "morality of indulgence." It sometimes has been called "fun morality." When hedonists pay attention to religious or social norms in addition to their primary emphasis on the pleasure principle, as they sometimes do, their position then loses some of its uniqueness and blends with one or both of the other two.

The absolutistic, relativistic, and hedonistic positions on sexual morality, as I have outlined them, are what Max Weber would speak of as "ideal types"; that is, they are logical constructs seldom found in pure form but useful in conceptualization and in the interpretation of data. In real-life situations, any given individual is apt to stress one type above the other two, but not necessarily to their complete exclusion. All sorts of combinations are possible.

The Relativity of Consequences

We shift now to a focus on the relativistic position, for here is where science can make its greatest contribution.

There have been a dozen or so serious research attempts in this country to determine if premarital coitus in any way affects the outcome of the marriage. In general, the approach has been to use presence or absence of premarital coitus as the independent variable and some measure of marital success as the dependent variable. Overall, the finding has been that marriage turns out to be more successful when premarital chastity has been maintained. But some of the reports have been inconclusive on this point, and in others the purported relationship was found to be of relatively low magnitude.

We can speculate as to why the studies so far undertaken are, in the first place, somewhat consistent in the direction of their findings and, in the second place, somewhat inconclusive because of the low magnitude of the reported relationship: abstinence from coitus before marriage is found to be associated with marital success probably because chastity has been considered the norm in this country and to remain chaste is in line with expectation. The statistical relationship between chastity and marital success, where found, has turned out to be of relatively low magnitude because of certain confounding variables that the studies have failed to take into account. It has not been demonstrated, for example, that premarital coitus is *in itself* the negative influence, as against an explanation that would argue that basic instability of the personality can be a single cause of *both* premarital sex experience and postmarital friction. Furthermore, since individual differences are concealed within group statistics,

it seems reasonable to assume that the magnitude of reported relationships may have been reduced by the fact of opposite effects in different marriages that cancel each other out.

In my own research, about to be summarized, I hypothesized that the values people hold and the norms of the cultures within which they live act as intervening variables to *affect the effects* of premarital coitus—with the greatest negative effects showing up where there is what I have labeled "value-behavior discrepancy."

This hypothesis was tested by comparing samples from sexually permissive Denmark, moderately restrictive midwestern United States, and highly restrictive Mormon country in the Rocky Mountain area of western United States. The study was made in 1958 and repeated in 1968. The latter set of data is only partially analyzed at this time. Nevertheless, results available from the more recent research fully support the following summary points for 1958 (insofar as they parallel each other):

1. Attitude measures supported prior expectation, in that the Danish respondents showed the greatest liberality of viewpoint on sexual matters and Mormon-country respondents the greatest conservativeness, with midwestern respondents in between.

2. Behavior measures, including rates for premarital coitus and premarital pregnancy, fell into the same cross-cultural pattern; that is, highest rates were for Denmark and lowest rates for Mormon country. The consistency of the two cross-cultural patterns demonstrates that behavior tends to line up with attitudes, though not always.

3. The discrepancy between how one behaves and what he believes was found to be proportionately lowest in Denmark and highest in Mormon country. In other words, norm violation varied directly with norm restrictiveness; the most restrictive culture (Mormon country), though having the fewest violators of chastity considered in the abstract, had proportionately the most who violated their own standards because their standards were stricter.

4. And it was this value-behavior discrepancy that was found to be associated with negative consequences. Proportionately, Denmark showed the lowest and Mormon country the highest: (a) guilt and other negative effects following premarital coitus; (b) forced or hurried weddings following premarital sexual activity; and (c) divorce-rate preponderance of premarital over postmarital conceivers.

To illustrate, TABLE I gives some comparative data on selected items from the 1958 survey.

Thus, it becomes clear that it is not the sexual act alone that determines the consequences but, more importantly, how this act lines up or fails to line up with the standards held. Norms and values are intervening variables, not only influencing the behavior but determining in significant ways the effects that this behavior will have. And it is value-behavior discrepancy, in all likelihood more than either values or behavior taken alone, that causes the difficulty.

In the research just reported, comparisons were across societies and concern was centered on cultural norms. But personal values are the individual counterparts of cultural norms, and we can assume that value variation among individuals within a society will show the same relationship to behavior and behavior consequences as does norm variation across cultures. Additional research is needed to fully test this out.

Some Next Steps in Policy Development

Policy, of course, entails value judgment. It is not the same thing as science, which strives for objectivity or value neutrality. Yet, properly utilized, each of these endeavors can be made to serve the other. Policy, when based on tested knowledge, is more likely to be successful in achieving the chosen goals. Science, when in line with broadly accepted values, is more likely to receive support and to have its findings utilized by society. Looking ahead to the possibility of further policy development in the area of premarital sex (and perhaps other areas also), I see the following major steps as necessary:

Table 1

Attitudes toward Premarital Coitus and Incidence

		Denmark	Mid-western U.S.A.	Mormon Country
Attitude (What one values)				
Percent claiming no preference for marrying a virgin	Males	61.0	17.6	5.3
	Females	74.1	22.5	10.8
Behavior (How one acts)				
Percent having had premarital coitus	Males	63.7	50.7	39.4
	Females	59.8	20.7	9.5
Percent Premarital Pregnancy (births in 1st 6 months of marriage)		24.2	9.4	3.4
Value-Behavior Discrepancy				
Ratio of experience to approval in premarital coitus	Males	.68	1.09	1.69
	Females	.74	1.19	3.28
Some Measurable Consequences				
Percent feeling guilt or remorse over premarital coitus	Males	4.3	12.1	29.7
	Femlaes	2.0	31.0	28.6
Ratio of divorce from couples having birth within 1st 6 months of marriage compared with 2nd-year birth cases		1.09	2.17	3.25

1. *Delineation of society's core values around which there is reasonable consensus.* Contemporary American culture is characterized by value pluralism, and perhaps to some extent this always will be so. It would be unreasonable to expect mankind ever to be in complete agreement with itself. Yet, all is not chaos, and with clear thinking coupled with research there could be a reduction in the confusion now existing. In the first place, we need to pin down the values on which there is general agreement.

As a start, let me suggest that most Americans today place high value on these five things: (1) the preservation of human life, (2) the maintenance of mental and physical health, (3) the search after truth and progress, however the latter be defined, (4) the right of the individual to freedom and self-determination, and (5) the serving of a common good through love and cooperation. The list may not be complete, and of course it needs elaboration and needs to be checked and rechecked frequently by survey research to keep it accurately descriptive of the *existing core values* of our society.

2. *Investigation of the consequences of alternative environmental and behavioral conditions.* After a dependable set of core values has been determined, this can be used as the reference point for research into cause-and-effect relationships. The core values would be considered as dependent variables, and the attempt would be to test out how various other factors either contribute toward or detract from the achievement of these agreed-on standards.

In my research into premarital sex, for example, it was first assumed that mental health and marital stability are accepted social norms and that such things as guilt or remorse over an act, feeling pressured into marriage or to hurry the wedding, and breaking up a relationship that was entered with an idea of permanence are "negative effects" —negative, that is, not in the context of ultimate or absolute judgment, but only in the relative sense of going against generally accepted norms. (They would seem especially to detract from items two, four, and five of our tentative list of core values. Of course, it already has been agreed that the list needs further testing, elaboration, and continual updating. There also is need to determine objectively whether and to what extent these specifics actually relate to the broader value scheme; divorce, for example, is becoming increasingly accepted.) It then was demonstrated in a small way that values and norms regarding premarital sex are intervening variables, operating to modify the consequences of the behavior. According to the criteria adopted, value-behavior discrepancy was shown to have negative effects.

Although this research represents but a start toward objectively getting at the dimensions of an extremely complicated problem, even this one tentative finding can be of some use in personal decision making and to the helping professions.

3. *Control over the physical and social environments to maximize their positive effects.* Once there has been built up an adequate body of dependable data describing relationships between environmental and behavioral factors and between both of these and an accepted set of core values, the next logical policy move would be to try to control the environment in line with desired goals. This is not the time or place to discuss such things as the depletion of natural resources, the pollution of our physical environment, or the pressure of population expansion—for they are given more detailed attention elsewhere in this volume by experts in these fields. Nevertheless, the problems are relevant to what we here are saying: man's potentials for achieving his goals are to a considerable extent dependent on the environment within which he operates. An important part of this, of course, is the social environment: norms and programs imposed by the society; cultural embellishments that both attract and detract; the quantity and quality of man's interactional patterns. Here again, I can only mention the phenomenon and leave its elaboration for other times and places.

Improving the social environment from the standpoint of better aligning

premarital sexual behavior with social goals would include attention to such matters as pornography and sex education. Both of these subjects are highly controversial at the present time, and research evidence remains meager and inconclusive. Pornography is regarded by some as a pollutant in the social environment; but, although this school of thought sees it as debasing sex and as a stimulant to undesirable behavior, there is another school that regards it as a catharsis or safety valve actually reducing antisocial behavior. As matters stand, there is no reliable body of data to settle the argument. Similarly, sex education is seen by some as an erotic stimulus akin to pornography and by others as a needed background for intelligent self-control. But there has been little evaluation research to determine which claim is correct or, more realistically, which *kind* of sex education is negative and which kind positive in its results. It should be obvious, therefore, that even before the environment can be improved in terms of social goals there is need for more and better sociological research.

4. *Encouragement for personal decision making responsibly carried out* Unless one takes either an extreme, absolutistic position (which surrenders individual choice in deference to deity and thereby projects the responsibility upon supernatural powers, however perceived) or an extreme hedonistic position (which goes all out for individual choice but dodges responsibility by stressing personal pleasure over obligations to others), he must somehow or other face up to personal decision making responsibly carried out. A responsible decision is one that is made in the light of evidence, with a willingness to accept the consequences, and with due consideration for others.

Responsible decision making by the individual is in line with democratic ideals and entirely compatible with the scientific frame of reference. In a society such as ours, indoctrination can be self-defeating. It may stunt the child's growth and leave him brittle and unadjustable. Learning is more than memorizing; it is analyzing and actualizing—in terms of carry-through for improved living. Rather than imposing preconceived values on the child, leaders need to teach the valuing process. This means listening to him, giving him a clarifying instead of a preaching or commanding type of response, helping him to weigh alternatives in light of their consequences, and assisting him to identify and develop his own set of values in the light of this ongoing learning experience.

Conclusion

Research underlies policy, or at least should do so in a scientific age. It provides the relevant raw materials needed both to formulate and to implement the policy structure of a society such as ours. Science, as has been noted, cannot go beyond the limits of empirical data, and so cannot make value judgments. But the social scientist can *study values as data* and, taking these and other relevant data into account, can demonstrate the varying effects of alternative lines of action. As scientist, he will avoid questions concerning ultimate worth; but the insights he can bring concerning the consequences of acts make him a discoverer of *relative worth*—and hence a collaborator in the formulation of policy.

Elsewhere I have described the major point of this paper as a *Theory of Normative Sexual Morality*. It is normative in the sense that its takeoff point

is values and norms. It represents a morality system in the sense that it provides a basis for personal choice. But it must be remembered that the values that can be derived from social science research are *values* only in a relative sense. We are talking about a morality of consequences, not a morality of absolutes handed down from above.

Finally, if our central proposition is correct—that value-behavior discrepancy is productive of negative effects—it then behooves policy makers to find ways to reduce that discrepancy. The decision whether to try to liberalize values to bring them in line with behavior, whether to attempt stricter control over behavior to make it conform with the values, or whether to work for certain quantitative adjustments in each is for the policy maker, not the scientist. Once such a basic policy question is settled, however, the scientist can again apply himself to testing alternative ways for moving toward the chosen course of action.

I will close by simply drawing a parallel, between this observation and what some other speakers have alluded to, particularly Dr. Emily Mudd, on the population problem. I am glad that Emily brought in the theme of values and the relevance of values to behavior and, I think, to the consequences of behavior.

Research on family size indicates that more important to the marital satisfaction of the individual couple, more than just number of children, is how that couple is able to control the number of children according to its desires—in other words, how the couple's values and behavior line up or fail to line up. And when the couple have more children than they want, or fewer children than they want, they are more likely to be unhappy than if they were able to control the number of children in line with their desires.

It is parallel to what I have been dealing with in the area of premarital sex, because precisely the same thing was found there. It is when you have a value-behavior discrepancy, when the premarital sex, in this case, or the family size, in the other case, is in violation of the standards held, that you seem to have the negative consequenes.

I would argue from this that social planners need to take into account the values of the individuals, the norms of the cultures in which they live as real data, and if the planning involves any particular goals, such as reducing the birth rate in population control, a goal to which I fully subscribe, ways must be found to modify the values that individuals hold relevant to these things.

Or, if you get the control without altering the values, you are going to get basic dissatisfaction in the people you are dealing with.

* * *

Mead: I would like to point out that we need to tie together our recognition of the population explosion and all its ecological consequences with the fact that this is the first time in human history when societies have been able to afford to release women from a primary obligation to homemaking. In order to bear enough children who would survive, most women have had to give their whole lives to homemaking and reproduction.

This bears on what Professor Murphy has said in his paper, but not in his speech, about our attitude toward creativity, because we will now have socially available women, as well as men, who can give their full time, or almost their full time, to contributions to society, and this will, in turn,

have tremendous effects: for the first time in history, society will have to give women public roles that are worth having.

When private roles and private recognition, and support and dignity, are withdrawn from women as primarily homemakers and the mothers of the next generation, we will then have to work out some way by which they can make comparable intellectual and artistic, philosophical and religious contributions to public life that we have committed to only a few men while all the other men were busy helping the women be homemakers.

* * *

MEAD: We have so far presented you with rather odd pieces of a picture puzzle, partly from two disciplines and partly on two subjects. So far we have been approaching the general problems of the environment rather circumspectly, with a bit of sex behavior, the information explosion, problems of population control, and Professor Murphy's hope that we will get psychology geared into the study of the environment.

We are now going to have a number of discussants, and first will be Dr. Ralph Tyler, Director Emeritus, Center for Advanced Study in the Behavioral Sciences, Stanford University.

TYLER: Some of you know that the Center was established by act of the Ford Foundation and leases land from Stanford University, but it is not actually part of Stanford University.

Also, you may have learned to your sorrow that about one-fourth of the Center was burned down the other night, when students and others, trying to burn the ROTC building at Stanford University, were repulsed by sheriff's deputies, and the only unguarded place around was the Center, so fire bombs were thrown there.

Coming back to the subject of the paper that was assigned to me, Education Balancing, Conditioned Response, and Responsible Claims—and although the formal paper outlines a proposal for dealing with both conditioning and with more flexible means of learning as a way of making a more effective transition in these days of rapid needs for transition in our society—I think we ought to be reminded that, by and large, education, up to this point, for the mass society, has not meant the schools.

The schools throughout the world have been primarily sorting agencies concerned with the problem of bringing that number of people who are able to compete for positions of the social-political-professional-business elite to the number of positions open in terms of the shape of that economy. So that when I was born, 61 percent of the United States labor force was unskilled, and only 5 percent of the U.S. labor force was engaged in managerial and professional occupations.

It was understandable that the school system used methods that are known—by those who study learning—to be inappropriate for learning, namely, having everybody moving at the same rate and using a grading system based on the lower part's always being given low grades; they then were discouraged and dropped out, so that by the time, in my day, children got to the sixth or seventh grade in the state of Nebraska, they could drop out of school; the number that dropped out was about equal to the number of unskilled that were needed.

With the increasing changes taking place in the composition of the labor force because of science and technology, today only five percent in the United States, and a somewhat larger but comparable figure in other developed

nations, are unskilled. The number in the United States who are engaged in meeting nonmaterial needs, health services, education services, recreation services, social services, accounting, administration, and engineering and science, now total 60 percent of the labor force.

So we have a demand for a much larger number of educated persons, and the educational system—that is, the formal system—does not serve the needs. Even in the United States, somewhere between 15 percent and 25 percent of our children do not reach a literacy level that enables them to engage in more than unskilled labor. The problem we face is developing a school system, a formal educational system, that makes use of what we know about learning rather than continuing a tradition that was, unconsciously perhaps, based on the business of regulating the number of people to the opportunities available to them in the social structure.

But, although at the primary level teachers, by and large, are more adept at influencing learning and at the undergraduate and graduate level are very little adept at influencing learning, by and large, persons who are called teachers are not very effective stimulators and guiders of learning. Therefore, in modern society the chief means by which mass groups attain their education or their learning are through their peer groups, their family, through the mass media and the like, rather than through the formal arrangement of the school. We find, for example, to take one illustration from Dr. Emily Mudd's presentation, that children develop not through any formal effort of the school but through the family, the peer group, through the fairy tales and other things, but by three or four years of age they have already developed the notion, on the average, that they want three or four children and that having a good many children is a fine thing.

Thus, the kind of goal we require is either massive systematic intervention or a very slow adaptation to the new expectations that come from other sources. But I am primarily concerned with trying to suggest a means of balancing conditioning, which is one form of learning, with a much more flexible and responsible process of learning. And it is the hope that, as we become more concerned with the effectiveness of our formal institutions, there will be more effort to use what is known about learning in the educational institutions, although they now are largely sorting institutions.

MEAD: Our next speaker is Dr. William Simon, Director, Sociology and Anthropology Department, Institute for Juvenile Research.

SIMON: I want to wander around and raise a number of points that have been discussed here. Two themes that to some extent have been repeated in a number of papers were the old familiar notion that we really need more interdisciplinary collaboration and that we become responsible to the environment in the broadest possible sense.

The first part is like the annual brotherhood luncheon; we ought to love each other more. In fact, we really do. I grew up both enjoying and suffering Margaret Mead and the work of Gardner Murphy and his students. I cannot conceive of a sociologist who has not. As one goes around to conferences, one finds in the inner recesses of the disciplines, people doing their own little nitpicking thing, and that is good, because it keeps them out of our way. That is why I really want the journals to continue, and I look at the people in our science, and thank heaven they are doing that, or they might get jobs that will do us some harm. I think that the crucial differences may not be differences of disciplinary loyalty, but I think there may be a substantive

distinction that cuts across disciplinary hang-ups. I have a kind of conservative-radical commitment. I think one of the great gifts of anthropology is that it really traumatized the 18th and 19th centuries by convincing man that his time and place did not express any principles or truths but were simply a moment in the sociocultural process that might really be going nowhere.

All our disciplines have helped us to that understanding, and we have always managed to walk away from it: namely, just as society changes in a very fundamental way, man changes, and in very fundamental ways, and he may be able to change very rapidly. And, confronted with the trauma of that realization, we invent things like ecology. And now, very clearly, the socio-cultural moments are changing to the eternal truths, and the softer psychologies somehow have invented love for us, forgetting that love is a very recent inconvenience in the history of man. The human-potential movement, half religion, half science, somehow goes back to William Blake to conceive for us an image of man full of all the basic instincts that somehow get crudded over by layers of civilization. We now have to get back to him.

I think if we are going to think about the future—and I think we have to think about it realistically—we must realize that the kinds of decisions we make will basically change the human capacity, the human sensibility. We have to accept the responsibility that we are designing men in very fundamental ways, accepting freedom as well as the responsibility it affords us.

I think people are going to go into the study of the social structure, the environment in the larger sense, and I think our colleagues have an instinct for the dollar; as more people go into environmental research, there will be an exodus—we have all seen them closing Washington agencies—to find out where the program really lies. I think the worst part of it is that we are going to drown in ecological and environmental research. In this situation, I think we ought to moderate our plea for more research lest the hordes descend on us and begin to pick the people who think they can do it without turning into a major industry.

Again, part of what I am saying is that the crucial thing that will now unite us, and the thing that we have to war over, is basically the kind of man we want to design, the kind of man we want. We saw this in many ways in Dr. Mudd's presentation—the notion of healthy sexual animals. I am not sure what that means. The impulse to mother is clearly one of the problems in getting women out of the hang-up of thinking they are fulfilling their natural impulse when they are serving a man and serving their children; unfortunately, we have to drive them out of that climate before they all kill us.

There seems to be a universal intent, including among the Catholic students, to use contraceptive devices, but only for family spacing, not for limitation: by and large in our society, as in most Western societies, to be a woman, to get your membership in the country club of women, you must have a baby in your arms between 25 and 40, and if you do not, the other women punish you, and so does society.

Let me address a remark to Dr. Price.

I have already suggested one of the things we have to get way from is part of the impasse in this environment, and that is the great culture efficiency—which, if we have any kind of world, is going to kill us. We have to begin to learn how to sustain and enjoy inefficiency, because this is the 20th-century version of the Protestant ethic, which had little to do with whether people leaped into beds with one another but had to do with something that is implied

in the emerging generation gap, and that is merely the capacity for pleasure, the capacity to turn one's activity into existential correlates and not consume one's life in the pursuit of abstractions. I think, as a terribly critical kind of point, the meaning of the Protestant ethic really was that the moral, prudent man demonstrated his prudence and morality by acquiring the capacity for pleasure and then doubled the debt by being doubly prudent and moral: by not spending it, he simply handed it on to his children, "I gave it to you; don't you spend it either."

I think we now have a whole generation, at least in middle-class America, possessed of continuous prosperity all of their lives, for whom things like cars are not great symbols. We have a group of kids who want to cash the check, and they are prepared to do what I believe will traumatize most of us, and that is to commit themselves to lives of inefficiency and lives that are, in many ways, frighteningly asocial. This worries me a little bit. The direction is healthy; there is a beautiful line that quotes one of the French students during the May riots, and he said that any revolution that demands you to sacrifice yourself is Daddy's revolution, and increasingly the kids won't have it; they are willing to put the fuse in on this existential level. And the worst thing we can do is maintain our need for "integrated identity," our need for stable relationships, our need for privacy and space; they represent some of the expressions of some kind of eternal truths. A couple of lines I used earlier deal with precisely the need for identity; let me end this with a few lines from Leonard Cohen in one of his songs. He has the following verse:

> "Come with me, my little one, and
> we will find a farm/and grow us
> grass and apples and keep all the
> animals warm.
>
> "But if by chance I wake by night
> and I ask you who I am/then take me
> to the slaughter house, and I will
> wait there with the lamb."

MEAD: Professor Klineberg, of the International Center for Intergroup Relations in Paris.

KLINEBERG: I am still convinced, in spite of the rather pessimistic comments here, that the social sciences do have a contribution to make in our attempt to understand and control the environment.

I feel, for example, that at least in three directions there is a very intimate relationship between the concerns of this meeting and the concerns of the social sciences. I think there are certainly data that are useful, particularly the knowledge of other cultures. I think that there are certain techniques that can be used of sampling and public opinion studies that have shown their value. And I think, perhaps in the first instance, of a point of view that needs to be added to the reflections of the demographer—that of the economist. The economist is also a social scientist, but in this case I will put him on the other side of the fence for a moment. We need also the biologist, and all the others who are attempting to understand our problems.

Nor do I quite feel as negative about the possibilities of psychological, sociological, and anthropological data's being used even in the highest places in the land. I would remind Professor Murphy that on May 17, 1954, when the Supreme Court decided that enforced segregation of Negro children in the

United States was against the principles of the U.S. Constitution, part of the justification for that decision—and you will find everything I say documented in the footnotes to the Supreme Court decision written by former Chief Justice Warren—part of the arguments used by the Supreme Court were arguments that came from a social science statement signed by anthropologists, sociologists, psychologists, all over the country, indicating two major reasons why enforced segregation was unjustified: one, that there was no evidence for the lack of capacity of Negro children to learn in the same way and to the same degree as white children; and, perhaps even more important, two, the fact that enforced segregation and any form of discrimination has a deleterious effect on the personality development of Negro children.

This is specifically mentioned, together with a very remarkable compliment to psychology in this Supreme Court decision, namely, that the reason for taking a different position today from that taken in 1896 (when it was stated that separate but equal accommodation fulfilled the obligations of the Constitution) was based on the developments in the field of psychology since that time. Now, this is one case where—and remember, I am not suggesting that this was the only reason for the Supreme Court decision—there was specific use of social science data, psychological, sociological, anthropological data, and it was not only read, but taken seriously by the United States Supreme Court.

I leave it to future historians to decide whether this particular act functioned as well as it should have, whether we have made enough progress in that field since that time, but the point is that here was the possibility of a movement all the way up from the social sciences to the Supreme Court, with the consequences that I have indicated, consequences that led many people, as you know, particularly a number of lawyers, to criticize the decision as being a sociological rather than a legal one. I think it was perhaps a little of both. I use the term "sociological" here the way the French do, to cover all the social sciences. But it is that term that was frequently used in criticism of this decision. So the first question I would like to raise with Professor Murphy and others is whether this experience gives us any possibility of expansion or extension to other areas, whether there may be other possibilities of moving a little further along in the influencing processes, or at least in the supplying of information to people in a position to make the responsible decisions. When we move a little more specifically to some of the questions raised, I would say first that the problem of relevant research as contrasted with basic research seems to me to be a false dichotomy, and one that I hope Dr. Price will have an opportunity to defend, especially if I misunderstood his position.

In France, as many of you know, at the time of what the French called the event of May, 1968, among the desires expressed by the students was, first, the desire for more interdisciplinary approaches to the various problems and, second, for relevance. And many of us were disturbed and unhappy because the desire for relevance seemed to exclude basic research. As a consequence, many people jumped to the defense of basic research, as if that were all that existed and as if relevant research were not a respectable activity.

I would like to propose that we keep both in mind—and here we may have to come down to the personality differences between social scientists; some are concerned with the most rigorous kinds of data collection or theorizing, without any notion of what this might do to the society in which they live; others are concerned with the social relevance of their work; many have been working with the techniques of basic science—Margaret Mead, Gardner Murphy—and many others have been concerned with applying the knowledge they have obtained to a better understanding of the problem of society.

So I would suggest that, instead of choosing between these, we regard both as legitimate exercises of the human mind; just as Roentgen was unconcerned about any practical application of the x-ray, so there may be people in the social sciences and elsewhere who are similarly unconcerned; perhaps today their data may be used. There are others who are impatient and want to see the research directed toward the specific problems of our day—now—today.

I see no reason why we should make the choice, speaking about science in general or social science in general. There is room in the mangers of science for both. I spoke of a point of view in connection with the contribution of the social sciences. We talked earlier about the population explosion, and I was struck by the almost exclusive emphasis on techniques of contraception, on the one hand, and, on the other, with the extrapolation of figures based on past experience to the notion of the doubling of the population within a given period of time. I heard no reference to a fundamental aspect of this problem, the attitudes of people—and the attitudes of people do change. The culture changes, and people change with it, or help to change it, and until we know something about where the movement of attitudes is going, I don't think we can say anything about the numbers of people that we will have in the future.

There is no easy way to introduce any statistics with regard to attitudes, but when I spoke of a point of view, what I meant was that these problems need to have added to their consideration that old, slightly outworn phrase, *the minds of men*, the attitudes and values of men and women about this whole area. Until we can find some way of introducing this concept of changing values, changing attitudes, changing positions with regard to contraception and population, we will not be able to make any predictions at all.

Dr. Mudd raised another point, quoting Margaret Mead, and I borrow the quotation from Dr. Mead as a very important one, in reference to the generation gap in the sense that our children are growing up in a world that we did not know, and they are telling this to us. It is difficult to estimate the rate of change, but as I look back now on a fairly long life of observation, at least of technological change, technological revolution, I would like to raise this question: Is this phenomenon that Dr. Mudd and Margaret Mead have described a temporary one or a lasting one?

I wonder whether, now that we have made these tremendous developments based on technological and scientific discoveries, the gap between our children and theirs will be anywhere near as great as the gap between us and our children. It seems to me that the changes that have occurred in our generation have moved us so far along certain lines that the relative changes in the next generation will not be so great.

Have I any right to say this? I don't know. But if it is true, then the problem of the generation gap or conflict or differences in the position of the young and less young in our present society may be a temporary phenomenon and not one we need to assume will be a continuing process in the future. Margaret Mead talked about the emphasis on wholes as the characteristics of the anthropologist, and there again I agree wholeheartedly. But the notions of wholes reminded me of a problem in which my colleagues and I have done some research recently. Our research touched on the attitudes of

African students in six countries toward their national as contrasted with their tribal identity. Our query was, to give a specific example for those of you who know Africa, does a Yoruba of Nigeria feel closer to an Ibo of Nigeria—I might say our work was done before the African crisis—than to a Yoruba in Dahomey? In other words, does the tribal identification predominate in the minds of the students, or does the national identification predominate?

We found tremendous variations from nation to nation and from tribe to tribe, and we found variations between individuals within each tribe. But the general movement did seem to be from tribalism to nationalism, this occurring at a time when many of us are concerned with the implications of nationalism in our own, older society, and a time when many of us are concerned with the excesses to which nationalism leads.

We try to cover many of our criticisms by speaking of chauvinism as contrasted with healthy nationalism, but as far as I know, no one has clearly drawn a line of demarcation between what might be called a healthy nationalism and chauvinism. Now we see in the other parts of the world that the building of nations is becoming a tremendously important aspect of their activity, a tremendously important concern to those responsible for the future of those countries. Here again we have a kind of anthropological warning: The things that worry us in one society may be the opposite of the things that worry people in other societies.

This problem, whether our concerns and our techniques and our values can be extrapolated elsewhere, that is, the need to understand the values, the beliefs, the desires of other peoples, seems to be of the most fundamental importance. Not very long ago, in Paris, we were talking about productivity and pollution. This is of great concern to us, obviously, and it is of great concern to this particular conference. But the developing nations have said: Pollution or no pollution, we want productivity. They want industrial and agricultural productivity, and they are literally at this particular moment—this may change later; I am speaking a little too dogmatically—much more concerned with increasing productivity than with reducing pollution. In other words, just the opposite position from that we are taking in our society. And whatever plans we make for the future must take into account these different value systems and different concerns. To quote one of my favorite lines from George Bernard Shaw: "The Golden Rule reads the wrong way; it should state, 'Do not do unto others what you would like others to do unto you; their tastes might not be the same.' "

MURPHY: I am very grateful that Otto gives us the constructive memories of 1954. What has happened, however, in regard to the many threats to the continuation of the human race reminds me of Alice in Wonderland, in which no matter how fast you run, you have to run faster than that to get anywhere. That is the issue we face with regard to the long series of Pugwash Conferences, which have reached a high level of clarity and competence but have not had any effect on policymakers vis-à-vis the actual suicidal threats that are mounting.

Will talks on arms limitation be influenced by science, particularly by social science, and particularly by the kinds of social science we have been talking about today? I think the inspiration of 1954 needs to be recaptured and intensified; the threat is greater today; there is a massive obligation of the social sciences to think about that kind of environment that makes possible the continuity, the only one that does make possible the continuity, of the human race.

DE SOLLA PRICE: A great deal has been said about the desirability of cross-disciplinary interaction. As a physicist cum historian making like a social scientist, I am very conscious of a particular difficulty, and that is that when social scientists talk about science, they mean their own science, and very rarely do they have any idea that there are fundamental differences between the behavior and texture of knowledge for a physicist, a chemist, an astronomer, or an engineer and for an anthropologist, a sociologist, or a psychologist. While there is a large difference affecting the very life of society, as in the relation between the basic research and the applied, there is the question: How many of your trained people does society want to hire for whatever they can do, apart from teaching, which gives you a feedback?

Sometimes we train anthropologists so that we can teach students to become anthropologists to train anthropologists. Society has a hole in the head if it pays for that alone. It is a very nice hole, and we would like to have it around, but what society is paying for is education. When, however, society pays for the same process for the physicist, it is paying not quite so much for general education but for the production of physicists who are—or until last year or the year before—hired in fairly large numbers to add to the profits.

What we now have as a crisis in the social sciences is that we are training rather large numbers of these people because they are useful in universities, because they are rather soft subjects. You can get 5,000 unemployed, trained sociologists in Paris alone. It is nice coffee-house conversation. In a way, that is the difficulty, to make coffee-house conversations out of physics—would that there were more of it. I am not trying to distinguish between brands of scholarship or slur my colleagues. I count myself a social scientist. But the communications differ, the places in society differ. They are as different as the Yoruba and Ibo tribesmen. There is a fundamental difference in application, and I am a little worried by those who would suggest that the social sciences should perhaps have an aim and go after relevance. This can be just a great boondoggle, and we do it at danger to the university and to civilization if we take money to do things they want us to do, rather than the things we know are possible. We still must, willy-nilly, do the research that has to be done in the fundamental, basic knowledge in sociology and anthropology and in the other social sciences, and we cannot subvert it to all the claims or relevance and do the jobs to cure the ills of society any more than the physicist or biologist can give us things that we want. All they can do is to work at what is there, and this is very difficult.

MUDD: I think Dr. Klineberg's question was: Will the generation gap be as great for our children's children as it is for us? Earlier in this conference, one of our speakers said that there probably were living species on other planets, and that we can already communicate as far as the sun. If this communication should be developed in the lives of our children's children, it is conceivable that the generation gap might be very much greater.

Another of our scientists said that perhaps the major discoveries, the revolution in modern science, had been made in the last 45 years. If this should be the situation, there is something quite different for our children's children.

Dr. Christensen spoke of moral values and gave something of his research on premarital relations and their effect. I would like to leave you with a conversation with two brilliant young university students who are training to be teachers and are in the A level of teacher training and have been living

together for the last two years, quite constructively, not married, but learning how to buy food, and to cook, and so on. They have told their parents and their grandparents just what their living situation is, and they feel not a bit ashamed of it. I asked a young man, the brother of the girl, "What do you think about the way your sister is living?" and he said, "It's not for me to judge; but if she did not love Bill sufficiently to marry him, she would not be living with him."

MEAD: In a sense, Emily Mudd said that if we have anything as great as getting into communication with other planets, this will probably create a generation gap. I was thinking that we might set up a colony on the moon, and the earth would destroy itself. If we were hit by a meteor and knocked off our axis, it might create a comparable gap. But otherwise this gap is unprecedented; it cannot occur more than once, without external intervention, that the earth becomes one for the first time and that we are all in communication with each other.

The other thing I think may happen is that we may learn how to communicate with our children. We may learn to communicate across lesser lines so there will be less of an extraordinary break, especially in value systems, than there has been in the past.

UNIDENTIFIED DISCUSSANT: I was going to put a question to Dr. Mudd, but I would like to connect it with what Professor Klineberg said; I think I am in much greater disagreement with him than with Dr. Mudd, because I think that maybe we will, in the future, be more bold and not tolerate dictators on either side of the pyramids; that is, we want to have human rights for black children in Nigeria as we have for white children in Europe, and we will not tolerate this kind of nationalism, not even in Africa. Perhaps we will want a greater freedom for women, not only in the northern countries, but also in the Moslem countries, and we will have birth control not only among the poor in North America but also in South America, regardless of what the Catholic Church may proclaim.

So my question is really, putting this more ambitious goal at the forefront, Dr. Mudd, what is your idea, for instance, in terms of liberation of women, of the most useful means of controlling the birth situation and the population explosion; how should it be implemented in countries where the Government and other authorities are working strongly against it? We cannot be content with changing the situation in Europe and North America alone; we have to consider the whole globe, even when the governments are working actively against it.

MUDD: I return—and I would like to hear many other comments—to the point that family planning is essentially a personal problem. I think it is going to be a personal problem no matter what position the government or the great religious bodies take. I do not believe that anyone can force people to have children or not to have children. I think it comes down to a personal decision, and this is why I believe that we have to use, as Dr. Tyler said, educational methods in ways that I don't think we have even thought of in terms of communication in a mass situation. If you have a government that is opposed to this, I certainly do not know the answer to that except to go back to the fact that you can bring pressures on people and give bonuses not to have more babies. All the maneuvering of men and governments in this connection has to go back to the feeling and attitudes and values that the women

of child-bearing age—and their husbands—have. This is where you have to do your communication.

MADDUX: I want to state very briefly a parable, and then I want to make a plea.

I am at the World Bank now. Prior to that I was at the Pentagon, and philosophy is my discipline, so that does not make me a scientist of any kind. When I was at the Pentagon—the Pentagon is the largest building in the world: there are 30,000 people in that building—and I was looking through the phone book one day, which is a very good way to get an education about modern America. I found out there was something called the Advanced Weapons Research Unit. There are the sort of people there you would expect. But to my tremendous satisfaction I noticed there were two behavioral scientists listed there. And I was working in the office of the Secretary of Defense, so I called these people and asked them to come up. This was about 1967. I told them there was some interesting work being done on the nature of aggression—Konrad Lorenz and people like that are writing books, and what are we doing here in the Pentagon about understanding what aggression is?

They looked at me rather blankly and said, "We are not doing anything." I asked them why, and they said, "You know, it's very difficult to get those kinds of projects through the military." I said, "Look, we are spending $60 billion a year allegedly to take care of aggression. Could we spend maybe $6,000 to find out what it is?" They said, "Look, we don't disagree with you, but it is not technically possible to do this. We don't have the staff." I told them, "All right, we don't have enough people here in the house to do it, but let's go out to the universities and get it done." They said, "No, we can't do that either, because nobody in the universities wants to do it, because everybody is so down on the war they don't want to take any of this money. This has become blood money."

How could anybody be against taking money to tell us what aggression is so we can stop it? Maybe we are committing aggression. They said, "You don't understand. It doesn't work that way." That was a very frustrating experience, and I am not exaggerating.

Now I am at the World Bank, and the man who was the Secretary of Defense is now the president of the World Bank. Among the many problems he has, he has that same one. We have about 200 economists in the World Bank, we have lots of specialists in various sectors—agriculture, transportation and power, et cetera—and we have many, many good people, and I am not knocking the organization, but there is not a single anthropologist in the Bank, to my knowledge: there are no other social scientists at all. There is one alleged philosopher, and there are a lot of economists and a lot of specialists.

Mr. MacNamara made a speech a couple of months ago here in New York in which he appealed to the development community at large, and that means everybody who is interested in development, the university, bilateral government aid organizations—everybody—and he said, in effect, Look, we're starting the second development decade, and we want to reach the new targets of GNP growth that have been suggested by very distinguished men like Professor Tinbergen. But we want to do something more than that in the Bank. We want to do something about the quality of life; we want to do something about social uplifting in these countries, and we need social indicators and we don't have them. He said that we have a tremendous number of questions and we don't have the answers. The bank has a lot of leverage. It lends

$2 billion a year. And the Pentagon has a lot of leverage. It has a lot more than $2 billion.

The point I am trying to make is: We dismiss these agencies, whether they are government or nongovernment, and we criticize them for doing a lot of harm. Perhaps they do, but my experience at the World Bank and in government is that we cannot find people who will come to us with workable ideas that our kind of bureaucracy can understand and put into operation.

I completely agree that we ought not to prostitute basic research. But if we want to change the world, the World Bank's whole purpose is to try to change the world for the better: it wants to change it in accord with the way the world wants to be changed. There are 112 member governments, so I end this with a plea: If you don't believe what I say, please write to me and I will send you Mr. MacNamara's speech, in which he says very clearly that we want research organizations, we want scholars, we want people to tell us the answers to some of these questions from all over the world. Furthermore, we are the only institution in the city of Washington that I know anything about that is hiring people; everybody else is firing people. We are doubling the staff of the bank in two years.

Consider me a mail box. You all have a standing invitation to come to lunch with me at the bank's expense any day of any week in Washington if you can tell me how we can proceed more intelligently. It is very, very difficult to get the kinds of information that we need to progress rationally in the kind of operation that the World Bank is engaged in. And I am putting the blame on you people; I put the blame on us. We don't know how to get in touch with you.

MEAD: I am glad this plea came from the World Bank, and not from the Pentagon, because we are looking forward in this whole meeting—as I understand it—to the creation of the worldwide instruments that will be able to muster all this expertise and create this kind of cooperation.

NG: I am glad Mr. Maddux spoke up, because I was thoroughly enjoying the intellectual exercise and I was wondering whether I was in danger of sitting on the other side of the fence. We think that we are separate, but I would like to point out that we are all in this together. First of all, I would like to point to the title of this Conference, "Environment and Society in Transition." Man is conspicuously absent in this, and I hope it is not inauspicious, meaning to say that man has disappeared in the process of transition. What particularly bothers me as a member of the younger generation is that the world we have been discussing, and the whole concern of this conference, is that this is a world that the younger generation is going to inherit.

I would like to point out also that in the current environmental-crisis interest, again man is conspicuously left out. It appears that man in this whole process is becoming a slave asked to clean up the environment, yet man is a very integral part of the total environment. And while we are cleaning up the mess, we also have to begin to clean up the mess that is man. Let us look at the world through the eyes of a child. To a child there is no environmental crisis. This is a world consisting of toys. Environmental crisis exists as it is perceived in the minds of adults. I am not denying the existence of a problem to be dealt with, but, unfortunately, in the process of growing up we substitute atomic reactors and supersonic jets for toys.

It seems at this time that environmental crisis is an artifact created by our artifacts, and unless we get dragged into creating more artifacts to counteract these artifacts, we had better begin to ponder what we are doing because, as Robert Oppenheimer once said, in the process of trying to save our own skins we may, by that very process, accelerate our own destruction by building more and more powerful weapons to counteract the existing weapons.

I am a neurologist, and I would like to share with you some thoughts that have been bothering me as to the state of man. The hard, cold pavements underneath us, as well as the existence of the Conference, are derivatives of a pulsating deep within us. I have no answers, but I want to pose some questions. Why is it that man, apart from several other species—namely, the red ant and the brown rat—is the only species that, as far as we know, organizes willful killing to any significant extent? Could it be that the external inconsistencies we are seeing in society today are a reflection of some basic "inconsistencies" that exist within us?

I want to toss out a hypothesis that has been proposed before: perhaps if we look at this from an evolutionary perspective, man is a relatively weak creature; he depended more on flight than fight for survival. Perhaps at that distant point defenses against killing were superfluous, yet when we began to invent weapons, first, the jawbone of a dead animal, and then sophisticated machinery, we took evolution by surprise. Now we have become a very powerful creature, and perhaps at that juncture we begin to invent defense mechanisms necessary for our survival. I want to ask, could it be that conscience, guilt, and all these responses are an invention that man invented as man evolved?

We have taken evolution by a second surprise; we now have weapons that kill at a distance, kill so rapidly in a millionth of a second that our traditional defenses are useless. These defenses will perhaps evolve in face-to-face combat situations, and I feel a lot of pity when I stab with a knife. I have a lot of pity when I see a dog run over by a car. I cannot sleep for days. Yet we talk about the pulverization of millions with detachment.

This is one of the problems I think we have to deal with: how do we go about inventing new mechanisms that will be effective? This is a task of cultural social engineering, and I would like to pose this as a question that hopefully the Conference will consider. I would like to bring up two points with reference to the generation gap. This is one way to look at it, from the quantification aspect: For a man living 6000 years BC, the doubling time of population at the time took, probably, 6,000 years. Today it takes roughly about 35 years, let us grant 100 years, to double. Divided 6,000 by 100, and you get 60. What this means is a man living 6000 years BC had to cope with a rate of change once in his lifetime. Let us equate rate of change with doubling time. Today, we see a doubling time in 25 years as the rate of change increases— and this is my point—to the very point where we begin to reproduce ourselves at puberty. In other words, the doubling time is 13 years. That perhaps may be a critical point, because before we are able to reproduce, we do not even recognize ourselves. And I leave this as a question.

ERAJ: Dr. Mudd has very eloquently dealt with the problem of population and family planning, but there are a number of points that should be considered. She has mentioned the pitiable plight of a woman having unwanted children and the effect it has on her health and the health of the baby. I will tell you that medically the unplanned pregnancy is the biggest source of mortality and morbidity in women between the ages of 16 and 44. It is not only that they have to undergo abortions; we know full well that when they keep on having pregnancies they are much more susceptible to many diseases. This

has led to a simplification of the solution. We have accepted that anything that affects the social, physical, and mental well-being of man is really a disease. That is why we call alcoholism a disease. That is why we call delinquency a disease. I do not understand why we cannot accept the unplanned pregnancy as a disease. This is what we have done in Kenya; clinics in Kenya are open to any woman to go and ask for guidance and help or assistance in family planning.

Now, another point was that reference was made to Japan, Taiwan, South Korea, and that family planning has been very successful there. I must state that family planning in itself was not very successful in those countries. The income per capita had increased, the living standard had become very much better in recent years, and family planning came along as a process of that evolution. It really did not start those trends. We have actually no example of any traditional society where family planning today has made any successful dent in the population.

You have asked the question, Dr. Mudd, will family planning ever achieve any control over population? I will tell you that it will never do so. We have never, scientifically, sat down and tried to discuss it, but where it has been practiced we know it does not reduce population growth. The population in the United States is going to increase by 16 million over the 1964 level. The population in the United Kingdom is going to increase, and in the countries where family planning has been practiced, it is going to increase. We have closed our eyes, trying to think that family planning will control the population and that population control will control the other evils that are prevalent today: hunger and stravation. This is not true. We in this scientific organization have a duty to limit it, but I don't think we will do it.

Now, we were discussing what could be done. It is known that if *some* money is spent on family planning, if *some* research is done, or if a quarter of the money that is spent on cancer, which does not affect as many people as are affected by unplanned pregnancy were spent on that, tomorrow we could devise a test paper so that every women would be able to tell by using it if she is or is not going to ovulate tomorrow.

Here again the question of religion would perhaps be circumvented.

LOWENTHAL: Dr. Eraj is right about the environmental crisis and children. Some of you may have noticed that in the kindergartens in New York City children were playing "garbage," and some of them would lie on the floor and get swept into trash bins by others, and there was no role that was preferred.

I would like to put a serious question to the working groups that will meet later, and this assumes that many of the questions that were asked this morning are soluble. I am speaking now of the questions of deciding how you get interdisciplinary work going in a profitable manner, of how we resolve the question about what is relevant and what is not relevant, of how we resolve decisions between what seems to be pure and what seems to be applied research? Efforts can be made through a great deal of such research to solve many of the hard problems of world resources and of environmental control, although I think not all of them are soluble.

What I would like to put in this question is: how can you persuade the new generation that it is reasonable to wait to solve some of the questions in the only ways that, presumably, they can be solved? I have in mind two special points here; one is that practically all the questions involving environment and

society are questions that require time to work out. The whole science of ecology is one involving problems that we cannot begin to understand until there has been time to see what the problems are. We do not know the answers in advance and it takes years, and in many cases generations, to know what problems are going to emerge.

In order to understand this, one must therefore have a sense of what ecology is about and one must have a sense of what history is about, and yet we see a demand everywhere not only for relevance and for activism, but for immediate solutions. I would like to have a consideration of how do we—assuming we think we know how to go about answering some of these questions—then proceed to convince young people and the world in general that it can afford to wait and undertake this kind of thing in the kinds of institutions that we have?

How do you avoid burning the Institute for Advanced Studies? How do you avoid having professors beleaguered in pursuit of what may be inappropriate methods of solution?

PERRIN: My first point starts from Dr. Eraj's concept that family and cultural population growth must be treated as separate entities.

I think there is a lot of truth in this; they should be considered as different, but deeply interconnected. And I think this should be one of the most essential tasks to consider in our working groups: how are family planning and limitation of population growth connected? For this, we should think of how it worked in different countries.

This is also connected with the fact that some governments are in favor of the extension of family planning, like the Indian Government, and others are against, like the French Government. And though France was the first country in the world to introduce family planning by private and artificial means—the limitation of the birth rate started at the beginning of the 19th century, and the consequences were that the population grew very slowly during the 19th century and started to decrease in the 1830s. We have countries in which conscious introduction of birth control has been a complete success, like Japan. It is an advanced country with a well-educated population, and there the attempt was a complete success.

We have the example of China, which introduced birth control in 1956 with great propaganda to reduce the rate of growth of the population, because it was too difficult to feed 15 million or 20 million more people each year. And after one or two years it was completely dropped from the political scene. And there were a few bad crops again, and again it was not so easy to feed 20 million more people every year, and a few years ago propaganda started again for birth control, but under the cover of family planning: it is good for a family to have not more than three children, et cetera. All this should be studied, to show the complete interconnection between the two problems.

We have problems of a rapid growth of population in the Soviet Union, but in Bulgaria, where the number of children per family is about 1.5 and there are far too few children, they are beginning to understand that it is dangerous for the country. It was easier for Bulgaria during the past 20 years to have this small birth rate, because it is expensive to educate and to raise children. But now they are facing a situation in which they learn that it is really against the natural situation of the country.

We have many examples in many, quite different countries. I think we

have to face, in this case, the opposition of some governments and the opposition of the Catholic Church: France was and is still largely a Catholic country, and during the beginning of this century there was a large difference in the number of children in a family without any religion, and the many more children in Catholic families. I have seen very good Catholics, very deeply religious families with only three children, and this is the number they wished, and they have no more. I don't know how they manage with the church, but they do. I think that these are things that will not fundamentally retard family planning when there is full information; even if governments are against it, and the church, it does not mean that it will not work.

MEAD: I will make one closing comment from this panel in reply to David Lowenthal's question: How can we get people to wait so they won't burn things down? I would suggest, by doing the things that need to be done; there is a systematic relationship between people who wait too long and people who then won't wait long enough. One of our jobs is to figure out how we can work out a balance between the things that must be done today, and if they are not done today, that will make a lot of people burn before tomorrow.

* * *

ON THE STATE OF PSYCHOLOGY

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If from a high tower above the world you could view in perspective the state of psychology as it takes shape day by day, what would you see? First of all, you would look at the universities. There, in a "life-science building" or in a building shared with other experimental sciences, you would see a busy hive of psychologists and their students, experimenting on human or animal functions with their new electronic gear, probing in skin and brain of mouse, monkey, and man. There you would also see the Psychological Clinic, with its interviewing and testing, sometimes utilizing the same gadgetry as the experimental portion of the department of psychology, but sometimes oriented more to the "talking world," especially the talking world of the life problems of child or adult. Throughout everything that is considered psychological there is emphasis on change, growth, development: how things got to be what they are.

In many of these university life-science buildings or other buildings associated functionally with them, there is also concern for the activities of men, women, and children, in their homes, neighborhoods, communities. One may wonder whether there is an effort on the part of psychologists—or of the university administration—to restore the balance between the "biological" and the "social" aspects of human life, although in terms of personnel, man-hours, space, and budgets, the balance would seem difficult to restore. What seems to be happening is the creation within the laboratory of a biological or, we might say, behavioral world. Because most biological laboratories are concerned with man in a planned laboratory setting rather than in the everyday "naturalistic" patterns of his life, his broad ecology may rarely be mentioned. The word *environment* and specifically the word *situation* are held to be appropriate in describing what makes him behave, but there is very little orientation to the sociocultural world as a whole. One does indeed discover an occasional "social psychology laboratory" rich in maps, photographs, and charts of urban trends, with real concern for the larger environment; but on the whole, this is the preoccupation of sociologists, or anthropologists, or political scientists, or economists. Vividly and pervasively one would therefore register the impression that a new biological science is being created, with intense seriousness and high ambition, and that the experimental methods of science are everywhere dominant.

The picture thus drawn emphasizes American university life: other research centers, such as Federal and state-supported hospitals and research institutes, would confirm this picture. In general, this identification of psychology with modern laboratory science would apply, on a somewhat reduced scale to other English-speaking lands, to Western Europe, to the Soviet Union, and in some degree to Japan. But for economic and other reasons these other lands show relatively more interest in the great historical questions ("the persistent problems") of psychology, represented in the United States by courses

in "history and systems," and a less concentrated concern with experimental methods, especially those that require expensive equipment. The trend described is, however, world-wide; even in India, Pakistan, and certain portions of Latin America, the new trend towards "hard science" is visible.

What are the *ideas* that go with this package? What is it that keeps the psychologists so busily and eagerly preoccupied? First of all, it is the behavior of organisms. Organisms are viewed in terms of their evolutionary history, their own individual heredity and life history, their functional capacities for receiving and elaborating messages from outside, their capacity to symbolize and represent within themselves the manifold of their immediate environing situations—with special emphasis on their capacity to benefit by experience, in order to adapt to situational requirements. The psychology of sensation and perception has a prominent place, but an even more prominent place is held by the psychology of learning. "Learning theory," abundantly documented by experimental findings and constantly changing as ingenious experiments alter the balance of evidence in one direction or another, takes the bulk of man-hours in many an American laboratory.

Behind this daily panorama of research on the behavior of living things, there is everywhere an identification with the general scientific point of view as represented, for example, in the journal *Science*, official house organ of the American Association for the Advancement of Science. Psychologists everywhere profess their intellectual and moral adherence to the goals and methods of science. The prevailing scientific world view as it has taken shape since the time of Galileo and Newton is imbibed by the young psychologist as he moves from the elementary course into his "psychology major" and graduate-student years. He may, as a student of social psychology or of personality or of clinical practice, belong to the "soft" pole of the modern psychological world rather than the "hard" pole represented in pure experimentalism, but almost as ardently he will pledge his allegiance to the output and the methods of science.

But in science it is legitimate and necessary, when you can't get into the subject matter directly with your hands and feet, as in building equipment, or running animals, or plotting curves, to *reflect* and *discuss;* and in the psychological laboratory and classroom you also *discuss* all sorts of issues, such issues as the life histories, or attitudes, or personalities of those who took part in some recent experiment. A "talking science," at a lower prestige level than a "doing science," has a place of secondary, yet real, honor in the total adventure.

If now we ask how such a state of psychology could possibly have come into existence, the answer lies in certain considerations relative to the general history of science since the 16th century. The revival of Greek and, especially, of Alexandrian science, along with gains traceable to the growth of mathematics and to incidental new knowledge from explorers, military, and naval men, threw into sharp relief the mathematical order of the world and the elements of mechanics as utilized by Copernicus, Kepler, and Galileo. The mathematical genius of Sir Isaac Newton made possible the development of astronomy and of a universal rationale in the form of physics. Then, late in the 18th century, came Lavoisier and a quantitative chemistry. Science was seized upon by the French, and a little later by the Germans, as a central part—and an ennobling part—of a rational and enlightened civilization.

The biological sciences took shape in their turn, especially in the German

universities during the early 19th century, followed, in the middle of the century, by the evolutionary tide of thought made dominant by Charles Darwin. The biological sciences were not as exact as the physical, but their proponents and adherents strove for exactness. The career of Helmholtz illustrates the movement from the exact observational and mathematical methods of the physical sciences, to the study of optics and acoustics as expressions of physiological function, rather than simply the study of lenses and tuning forks as physical objects.

There was a possibility for psychology, through this developmental era, to become a science in the serious sense; that was the possibility of dealing with the living organism in essentially physical-chemical terms, using the methods, especially the experimental methods, of physics and chemistry. As soon as a biological platform was established on which to stand, one had to develop a "physiological psychology" of the processes of *perceiving, learning,* and a little later even *imagining* and *thinking,* in which the methods of the laboratory would be given maximal play.

All this happened exactly as one could predict, and, late in the 19th century, the German universities began their march towards a quantitative and systematic experimental physiological psychology. The social sciences were in the meantime borrowing as much as they could from the physical and biological sciences, especially from psychology; but there was not enough of it, nor was it scientifically good enough, to enable the social sciences of that period to compete. So psychology took its shape without benefit of any serious contributions of scientific methods from the social sciences to influence the laboratory-minded experimental scientists. Sociology and anthropology, political science and economics, though dealing imaginatively with vast quantities of complex observational material, could not claim the status of science, and before long psychology became crystallized as a biological science with only incidental utilization of social science methods and concepts. We see how the stage was set historically for the one-sided psychology which we described above. The physical sciences had essentially established both the problems and the methods for the biological sciences, and later for psychology and the social sciences.

As Kurt Lewin has pointed out, there were some unfortunate, even destructive, consequences. For one thing, much of the world of physics and chemistry relates to reversible operations in nature. There are reversible reactions in chemistry. In physics objects may go back and forth, up and down, with energy conserved but patterns in time-space conceivable as ultimately bidirectional. For the developmental sciences, notably for evolutionary biology and for individual growth, this would be a fantastic assumption. Hand in hand with this is the fact of *uniqueness* in individual development—a grossly misleading assumption when one speaks of atoms or molecules, but a patent fact of primary reality in the life sciences, specifically in psychology.

This is my attempt to answer truthfully the question regarding the state of psychology—as seen from a psychologist's point of view. But there are other points of view. A literate nonpsychologist would probably suggest that the richest source of information about individual personal development available among modern psychological methods is the yield from the work of Sigmund Freud. Whatever the controversies regarding his work, Freud did much to define the intricacy of those aspects of personal life that operate outside of

personal awareness and that make for its happiness or sorrow, its effectiveness or failure. It was Freud who, through a theory of the "dynamic unconscious," showed how the biological and sociocultural forces that make their impact on early childhood growth predetermine the individual towards a particular vision or blindness, a specific enthusiasm or revulsion. The clinical psychology that emerged began, in the early years of this century, to glimpse a richer and more complex world from which dreams and fantasies, ideals, and ambitions took shape in the family and community interactions of normal development. The contribution to psychopathology was conspicuous, but this was a minor point compared with Freud's massive impact upon the understanding of individual growth as a function of biosocial forces: love, fear, hate, injured self-esteem, as all of these made their sorrowful way through the record of the early years. Very much in the same manner in which physical disease has forced medical attention to basic issues of life, growth, and health, aside from all specific disease processes, psychoanalysis and the related dynamic psychiatries of the last seventy-five years have drawn attention to biological and biosocial issues that were scantily considered until the new clinical context and clinical observations were available.

Cross-Cultural Psychology

There are, however, still other ways of gleaning psychologic perspectives. The cross-cultural methods and findings, both in their own right and in association with dynamic psychiatry, have forced the development of new perspectives all along the line. It is not enough to be told what everybody knows: that the social environment "shapes personality." The issue is different when we confront the fact that the oedipal situation may take forms different from our own when the child's hostility to a frustrating disciplinary agent is focused on the mother's brother rather than the father, or when we read that a certain schizoid "awayness" in the adult may reflect the mother's trenchant teasing habits of the small infant who has learned that all which is warm and good must be given up forever, or when one learns that the quality of parent-child relationships may alter the ideal ethical and religious system to a point where the cosmos as a whole and all its laws reflect the pattycake world of infancy. We may brush aside all such suggestions but we come guiltily back to the question: "Why have we not thought of the possibility that the emotional struggles in the growth period cast long shadows over the deepest issues of adult living." Or, as James Harvey Robinson said, "We are children at our most impressionable age."

The social science view, often in conjunction with depth psychology, has created a massive impact on our civilization, and it is clear that whatever the well-controlled and accurately described results of animal or human experimentation may yield, in the long run the results will have to be seen in the perspective of the historical and cultural science modes of observing and thinking. It is one humanity, not a diversified ragbag of scattered human images, that serious science will have to confront.

But perhaps we have not named all the resources for a study of man that could help in planning for the decades ahead. We have mentioned experimental, biologically oriented psychology, sociocultural psychology, and clinical psychology. But what shall we say of the status today of the huge fund of human observation, reflection, and wise utterance that comes to us from folklore and history and from the biographies, the letters, the skillful interpretative studies of unusual men and women—all standing in their magnificence, apart from the texture of modern science. Must all these sources of psychological insight and reasonable hypothesis be swept away today by the more systematically oriented psychological scientist? G. W. Allport speaks of ways in which "personal documents" may offer at least hypotheses and, perhaps in many cases, good generalizations regarding the attributes of boys and girls that may presage the attributes they manifest as men and women. The psychologist may take Euripides or Shakespeare, Pushkin or Ibsen, as his source for a delineation of human nature or for the definition of unique attributes of specific individuals. A "psychology of personality" suitable for the study of Goethe or Darwin has made use of social, historical, personal sources of all these types and has, for nearly a century, received and turned back to the literary world conceptions of individuality effectively used by the modern psychologist.

Ecology

From the viewpoint of all the psychologies considered thus far, psychology is concerned with the behavior of organism. In view of the fact that the life sciences are concerned with the interaction of organisms and their environment, one might think that the environments in which psychological events occur would be studied in a very sophisticated fashion. In a sense this is true. But it is soon learned that it is the *immediate* environment, the laboratory room, the stimulator, color-mixer—or tone, or food pellet, or electric shock that is regarded as the energy package that is impinging upon the living subject.

Occasionally the time of day will be of interest, and one may think of the earth's magnetic field or of broad weather and climate factors as making a difference in a subject's behavior. There are superb modern research rooms in which light and shadow, temperature changes, air currents are nicely controlled and measured with excellent photography and cinema. One may attempt to bring the "macrostructure" of the social environment into the laboratory setting. It is generally agreed, however, that to *simplify* the stimulating conditions is a scientific virtue, and it is generally held that there is no feasible way to study the social life of man by the more hard-nosed procedures that hold the greatest prestige.

What can one do about this? At least three things: First, by the procedures just mentioned, one may simplify the macrostructure. One may, as Sherif has done, create a laboratory situation that produces essentially the more naturalistic human situation response pattern. Noting that men in society, from their different vantage points, make different interpretations of events going on before their eyes, he has standardized a variety of devices by which their convergence of judgments, when exposed to one another's pressure, can be observed and measured; i.e., men in the laboratory who at first disagree move from great disagreement to less disagreement—or may, indeed, move towards identity of report in what they observe. Large issues remain in regard to the persuasibility, suggestibility, negativism, obstinacy, or the various idiosyncrasies of men in society as they make everyday social judgments, as has been observed in these and many other studies. Just as the industrial psychologist creates a miniature man-machine system that duplicates the larger man-machine system of assembly line or cockpit, so the social psychologist attempts to capture all the essentials of the free-flowing social life of everyday.

A second path open to the social psychologist is the establishment of principles or "laws." By gathering large quantities of representative data in which samples of situation-response interactions can be observed, and, noting the dependence of the responses upon the attributes of the situations, he builds a primitive *ecological psychology*, in which emphasis is placed on the demand properties of the situation. Outstanding here is the work of the Midwest Research Station, Oskaloosa, Kans., under Roger Barker, and Herbert Wright and their colleagues. In this approach the experimental method is wanting; it is the controlling role of the situation that inevitably receives primary emphasis. One records and classifies the types of behavior that characteristically occur in each clearly defined "behavior setting," such as church, school, or street corner.

Third, one may place one's emphasis on *individual differences* in response to behavior settings, as has been done by Gordon Allport, Kurt Lewin, and their students, or one may actually succeed in considering both the special properties of the situation and the special properties of the individual person and attempt to see both in interaction.

But had not the public opinion and market research specialists already taken these various steps? Had they not, even in the days of Stuart A. Rice, studied behavior quantitatively as an expression of a given region—comparing the farmers of fertile and of barren land, for example, with reference to their views on simple economic and political issues, and then gone on to compare the response of these farmers or other citizens by the use of "cross-tabulated" data concerning the age, religion, and other attributes of these individuals? Yes, the economists, political scientists, sociologists, and anthropologists had indeed already made these studies of ecology and of individuality, and of these two factors in interaction; and in spite of the identification of the individual research men with the specialty to which each belongs, there has been in recent years a good deal of intercommunication between psychologists and these other students of social behavior. Everyone wants to be "cross-disciplinary." Occasionally there will even be a *clinically* and *personally* oriented study of public opinion or of social attitudes, in which the massive pressures of daily life, region by region, town by town, are brought into relation to the individual-response tendencies of specific persons. But from the social-science point of view, the tail wags the dog; the studies of individuals again overwhelm the studies of social settings. The clinical information available about an individual observed in a modern clinical setting (life history, health history, autobiography, psychometric and projective tests) so far outweighs in mass and in relevance the best we can gain in ecological terms that the imbalance appears absurd. It is as if we had the most marvelous information about a tropical humming bird and all we could say about its ecology is that it lives in a large cage.

Why, then, is the confrontation not seriously, intensively, deeply considered and the integration of all these materials not seriously attempted? The question brings its own answer in the form of another question. *Who* could effect this integration? One may say: the psychologist, of course; he who has given his professional life to deep probing into these issues. But for the most part, the psychologist has been absent when the roll is called. His professional image of himself, indeed the deep channeling or cathexis of his scientific love, has drawn him towards the specialized biological world of science. Science with a capital S. Even in the liberal-arts preparation he received, he had begun to eschew the mushy issues of social science, and his measure of maturity has for him progressively fixed on the degree of his adherence to a hard-nosed ideal. If he

belongs to a clinical, social, or other "applied" branch of psychology, he will not know enough about biological methods and results to be taken seriously when he discusses them. And indeed it will be evident that his aim is poor, his touch gauche, when he attempts that breadth of integration in which all the views of human kind would be made to coalesce.

No, the psychologists who can effect this larger integration are few; indeed, they are hardly to be found. The William James kind of psychology, with its medical and its philosophical integrations, has long since been an idol of the past to which we turn back, like Lot's wife, to be turned, if not to salt, at least to a stony helplessness. Here and there flashes of insight into the modalities of such an integration may occur to us. We have already noted that Kurt Lewin and his followers made noble sallies into this domain. Erik Erikson, with his clear delineation of biological growth stages and his vast preoccupation with preliterate and advanced societies as expressions of psychoanalytic dynamics, has kept the flickering light alive. But among the men who have matured and undergone their specialization within the last 20 years, it would be hard to find any who actually lived through the days of their lives in such preoccupations as are demanded today. If humankind is to have such wisdom, it will be a bit easier to formulate and express if the young psychologist has training in at least the elementary methods and facts that go with participation in today's scientific and philosophical undertakings.

But we do not really have even the methods and results to offer to an earnest, brilliant young integrator if he should come along. We have a lop-sided psychology, a psychology of the organism, not a psychology of men, women, children, and society. The inexactness and fuzziness of much social psychology is shared by sociology, anthropology, political science, even most of economics and human geography, and our young man would not only have to be offered a vision of integration but some extensive and serious scientific understanding of human ecology.

But what are the problems in creating such a scientific ecology? Such a scientific ecology is taking shape, of course, around the more organized factual domains, the physics and chemistry of pollution, poisoning, and malnutrition by inadequate, faultily balanced or faultily processed foodstuffs. When people themselves, as the environment of a given individual are considered, elementary measurable units, as in "population density," come into the reckoning. A well-known experiment by Calhoun describes the pathology that develops among rodents under conditions of extreme overcrowding, and human ecologists dream of a time when similar exact documentation of the effects of overcrowding could be made by the urban sociologist. But it is entirely possible that a complex of psychological factors having to do with loneliness on the one hand and lack of privacy on the other, with pressures toward competition, toward forced cooperation, toward pathological loss of self-awareness or inflation of self-awareness, and a host of complex psychological responses to a manifold of types of interstimulation, may within two or three decades give us a human ecology. It would be concerned much more with human *interpersonal* pressures than with response to industrial or human waste or to the sheer geometry, mechanics, and biochemistry of changing personal contacts. Ecology as a psychological science would then be different indeed from the ecology of today. Development in the direction of the newer ecology will come from the creation of new models of interpersonal relations and their testing through observation and experiment and, above all, through extrapolation and the discovery of

weaknesses and necessary corrections in models. On a rolling and pitching ship a gunner must aim not at the invisible target ship controlled by an unknown distant admiral but at the probable position the zigzagging admiral may have assigned to that target ship at that *future* moment. One-dimensional predictions based on one-dimensional extrapolations are probably worse than useless. The serious science of society organized in time-space units, of course, but organized also in higher units of individual and group purpose, will have to see where we will be when we need to use the specific new methods now in the process of being invented. Relevant science will call for the fantastic multidimensional thinking that alone can cope with such multidimensional problems.

Our argument regarding status (*qua* scientist) as a major factor in the determination of the world outlook for the young psychologist must, however, evoke one very large exception. It is not experimentation as such but rigor, clarity, order, the inescapability of the documentation of a fact or principle that constitutes the prestige-bearing aspects of science, and the world of *mathematics* possesses this on the same footing as does the world of experimental documentation. It would be ridiculous to maintain that the theoretical physicist, with his complex capacity to use mathematical reasoning, is automatically inferior to the experimental physicist. No such invidious distinction can be made. The time for a similar development appears to be ahead in psychology. In fact, Cronbach has already signaled this event, for mathematical psychology—or what are called today mathematical models of psychological events—is coming to have the same status-bearing qualities as experimental method. It is likely then, as mathematical sophistication increases and as the capacity for stating an issue in mathematical terms becomes more and more understood and respected, that the new pschology we are trying to describe will be both a mathematical psychology and an experimentally validated psychology. When experimental verification is impossible, the mathematical method will prevail. This means that the development of higher-level mathematical training will be more and more important for the psychologist and that types of social reality that admit such quantitative method will begin to play a larger and larger part in the ecological psychology we have been describing. It is to be feared that this will usher in another type of lopsidedness, if those future ecological relationships that can be well predicted prove more and more an inducement to able young psychologists to become specialists in ecological problems. But as they do so, they will choose those particular ecological problems that are most readily converted into the kind of thinking respected by the men of the mathematical models. As long as our prestige needs are fixed at the level of exactness, it will be the principles that are "clean" and bare, rather than those that are most comprehensive, which will become the center of our science.

EDUCATION: BALANCING CONDITIONED RESPONSE AND RESPONSIBLE CLAIMS

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If modern man is to survive and is to realize his potential for intellectual achievement, for human fellowship, and for deeply satisfying esthetic experiences, he must be capable of coping with change, be skillful in attacking new problems, and be open to and seek new experiences, including new human relationships. Education that inculcates "final answers" to questions, that forms rigid habits of response to symbols and other stimuli, and that develops a perception of the world as fixed and ethnocentric is maladaptive for the species and, as well, denies the individual the kind of life that is most fully human. Yet man has made much greater progress in perfecting techniques of conditioning human behavior than in developing learning situations that are conducive to acquiring the attitudes, understanding, and skills essential for responsible human participation in this rapidly changing postindustrial society.

Behavioral science fiction, such as Aldous Huxley's Brave New World and Orwell's 1984, furnishes a vivid warning of the perils of regimenting people by the use of systems of immediate reward, hypnosis, and drugs. Fortunately, the experimental evidence affords much less support for the belief that men can be as fully conditioned as these books imply. Nevertheless, most of us have been and are being conditioned to a larger degree than is necessary or desirable for a responsible citizen in a world society. What is a proper balance, and how may it be attained? These are questions for which no generation will have final answers, but each generation must seek a balance that appears to provide for both stability and change, recognizing that this balance is a dynamic and shifting one.

As a background for this discussion, a general conception of human learning that includes conditioning as one type is useful. Human learning is the process by which one acquires new patterns of behavior through experience. When one carries on a new behavior pattern and finds it satisfying, he continues it until it becomes part of his available repertoire. Then it is said that the behavior has been learned. The term behavior is used here in the inclusive sense to refer to all kinds of human reactions—thinking, feeling, and acting. Thus, one can learn a new way of attacking problems, he can memorize a statement, he can perceive persons, events, or situations in a different way, he can respond to esthetic elements to which he did not respond before, or he can respond to them in a different mode, and he can learn to swim or to drive a truck. In short, any kind of behavior a human being is capable of carrying on can be learned, maladaptive behavior as well as behavior that has great survival value.

The term "conditioning" is commonly used to refer to the learning of a behavior which is initiated by a clear stimulus and consists of an automatic,

fixed response. Most of the behavior of a driver of a car represents conditioned responses to traffic lights, to the approach of other cars and pedestrians, and to the sensations that he receives from the car's movements. To be a good driver, he must respond swiftly to stimuli that present themselves suddenly, and he has no time to view the traffic scene from various perspectives and to analyze the several traffic problems that might be identified. For most people, habits of cleanliness, of eating, of punctuality, are conditioned responses. The way we respond to authority, to brothers and sisters, to strangers, includes a large component of conditioning. The demands on a man for reactions in modern society are so great that he would soon perish if each one had to be examined, analyzed, and dealt with in a problem-solving way. Hence, conditioning is a necessary and important type of learning. An attempt to eliminate it altogether in an educational system would be disastrous. It fails, however, when it furnishes an automatic response where such a reaction is inappropriate. The problem is to identify the situations where conditioning is essential or at least helpful and the other situations, where a fixed response is not only not essential but where it would lead to the destruction of the species or the denial of significant opportunities for man's fuller development.

How can one make the distinction? It can be made only as an approximate adaptation to the present and foreseeable situations. Habits of eating, sleeping, exercise, speaking, obedience to accepted rules, coding and decoding stylized symbols are likely to be seen as requiring automatic responses, so that conditioning is a proper means of learning. However, we recognize that our society is undergoing continuing change, and we can conceive of the possibility that some of these types of behavior will require re-examination and the formation of new patterns. That is, human education seeks to help the student understand human behavior, particularly his own, and to be able to choose new learning objectives and to work on their attainment. In this way, each generation has a means for re-examination and self-renewal of even basic habitual reactions.

The inadequacy of conditioned responses arises from the changing environment, which requires new human behavior patterns for coping with these changes, the increasing understanding of the world and of man, which opens new possibilities for men to achieve their aspirations by effective utilization of the new knowledge, and greater acceptance of the ideal of the brotherhood of man and a world of greater equality of opportunity, the attainment of which requires new attitudes, skills, and deeper understanding. Conditioned response learning does not furnish a model to guide education that enables men to deal with a changing environment, to gain and use new knowledge, and to form and strengthen new relationships of man and society. These more general and dynamic goals are attainable through a more complex model.

One that is compatible with the development of responsible men in a changing society conceives the learning situation as one in which the learner himself seeks to acquire new behavior and the rewards of learning include the satisfaction of using the new behavior successfully as he copes with the problems he encounters. In animal conditioning, the trainer seizes on incidental reactions of the animal that represent a piece of the total behavior the animal is to be trained to carry on. He seizes on this animal reaction by reinforcing it, that is, by giving the animal a reward of some sort. This reinforcement is continued when the animal repeats the behavior until it becomes an habitual response to a stimulus that the trainer has chosen to use as the trigger. Similarly, other pieces of the complete behavior pattern are reinforced when the animal

carries them on. Incidental reactions rather than intentional ones are the common bases for conditioning. Consciousness and understanding are not necessary and may interfere.

On the other hand, the development of the behavior required for human responsibility implies consciousness on the part of the learner and an increasing understanding of the goals of his learning and their means. Hence, an initial step is for the learner to perceive learning goals that he will put forth effort to attain. We often wonder why a child will spend so much time and effort to learn to speak, or to play baseball, or to acquire a new dance step and yet seems to tire very quickly when working on school assignments. In the former cases, he sees others speaking, or playing baseball, or dancing and he can see that they are getting satisfaction from it. Furthermore, he can perceive at least roughly what the behavior is he is trying to learn, so that he can emulate those who seem to be carrying on successfully. It is all too rare for teachers to demonstrate in their normal actions much of the behavior they would like to help children learn, and even more rare for them to express in ways children can perceive how meaningful and satisfying this behavior is. Hence, a considerable part of the motivation for learning in school is based on the child's desire to make good grades in order to get along or to avoid reprimands or failures rather than the desire to learn what the school attempts to teach. Furthermore, the students' perceptions of what they are trying to learn are inaccurate and frequently in conflict with the desired objectives. It is important in this connection to recognize that for education to go beyond conditioning, the learner must perceive something to be learned that is attractive to him, or, to use the current phrase, it must be relevant and meaningful. He must also see clearly enough what he needs to learn so that he can take the initial steps in emulating this behavior.

This model of learning also includes rewards for the student as he successfully carries on the behavior he is seeking to learn, but the nature of the reward system itself must be consistent with the role of a self-directive, responsible person. Students should be helped to discover the satisfaction that comes from having acquired and used new understanding, new interests, new attitudes, new skills, rather than depending largely on the rewards that are extraneous to the learning itself. As a student develops character structure and conscience or, to use another current phrase, a stable self-image, rewards that arise from learning what he believes is in harmony with this self-image are to be preferred to rewards that depend on the favor of others. The techniques of conditioning commonly place great reliance on rewards that gratify appetites. These are played down in other learning models, because habitual responses to physical gratification makes a human being more dependent on those who can use force and material power than on those whose importance derives from intellectual or social influence.

Another feature of this model of learning is the availability of opportunities for practicing this new behavior until it becomes part of his usual repertoire. Availability of opportunities means that there are many chances to carry on the behavior and also that the student has time for the necessary practice. Too often, students spend most of their time in school passively while the teacher performs rather than actively engages in the thinking, feeling, and acting that they are expected to learn. Daily, weekly, and yearly school schedules need thorough reconstruction to furnish time for complex learning required for responsible human living.

Another aspect of opportunities for practice is that they should be sequential.

Sequential practice means that each subsequent practice goes more broadly or more deeply than the previous one. Sheer repetition is quickly boring to the learner and has little or no further effect. Only as each new practice requires him to give attention to it because of new elements in it does it serve adequately as a basis for effective learning. That is important for the student in gaining understanding, because it means that concepts and principles are brought in again and again, but each time in new and more complex illustrations, so that the student continually has to think through the way in which these concepts or principles help to explain or to analyze the situation. In developing a skill, it is important to see to it that each new practice of the skill provides opportunities for greater variety or complexity in its use. Sequence is also important in the development of appreciation, for it means that each new work of art should be demanding something more of perception and be providing opportunity for a greater variety and depth of emotional response.

This model of learning also includes some kind of feedback by which the learner not only is informed that he is successful or unsuccessful in his attempt to carry on the behavior but also is furnished some analysis of his unsuccessful efforts that can serve to guide him in his next attempts. Many forms of feedback are possible, varying with the type of behavior being practiced, the conditions under which the practice takes place, and the availability of human aids and technological devices. For example, videotapes of a human situation furnish feedback for a participant, but if such tapes are not available, the student's own effort to recall and reconstruct the situation and review his behavior in memory can be a crude but useful form of feedback. A colleague's notes, samples of one's products, comments of friends, criticisms by teachers when based on dependable observation, can also be used. Feedback is important because a learner who attempts to change inadequate behavior into successful practice simply by trial and error finds learning very slow. He is often discouraged and gives up. Some means of indicating to him more promising reactions serve to guide him and usually improve his learning.

The purpose of outlining this model in some detail is to show that there is an alternative to conditioning as a conception of learning that can be used in the planning and conduct of education designed to develop persons who are socially responsible, humane, and self-renewing. Too often, those who question the use of conditioning offer no definite alternative that can guide practice. More commonly, critics of conditioning expect that the spirit of the school or the undefined interpersonal relations, particularly the relations between pupils and teachers, will develop children into "good specimens of humanity." Some even profess that the content inherent in certain school subjects liberate and develop the responsible man. Evidence does not support this claim. If schools generally are to become effective in helping to educate responsible human beings, there must be available a conception of the educational tasks and the means of accomplishing them that furnish a constructive basis for the work of the school. The model just presented is one such possibility. It is not a vague, global conception but delineates features that can be defined, principles that can be followed, criteria that can be used to test the effectiveness of the model in action. Systematic efforts to develop responsible men can be made.

Thus far, the discussion has centered on the nature of conditioned response learning and of purposeful learning and the need for both. We now turn to an examination of the interrelations and balance between these two ways of

stimulating and guiding learning appropriate for the education of man in the contemporary world.

First, it should be clear that there are ambiguities in both conceptions of learning that make it difficult or impossible to predict in the case of an individual person whether a situation constructed for the learning of a particular behavior pattern will be effective and what the individual will learn. This ambiguity arises from the complexity of human beings. Even a small child has a range of drives and motives that result in differential response to situations offering particular rewards. Although most children respond positively to the offer of food, an individual child may not be hungry or he may be more concerned for the approval of a friend, or his image of himself as a stoic may result in a negative reaction to a food reward. As a child grows up, his hierarchy of drives, motives, and satisfactions develops into an individual pattern that helps to characterize him as an individual. This pattern can be one in which sensual gratification and social approval are high, in which case he is quite easily manipulated by the power and weight of others, or the pattern can be one in which hard work and helpfulness to others have become major features of his ideal self-image, in which case it is difficult or impossible to get him to learn behavior that he perceives as in conflict with these characteristics.

A second kind of complexity in the human motivational system is in the extent to which the individual postpones immediate gratifications for more distant rewards that he perceives to be greater. Some children have discovered that greater satisfaction is obtained by picking up their toys and washing their hands before running to eat because they obtain a warm response from Mother as well as getting a meal, whereas when they dash in to eat without these preliminaries, they may not get the meal and they do not get Mother's warm approval. The vividness of the human memory makes it possible for one to keep in mind and to anticipate the joys of an achievement that requires a long time to complete, so that he will forego many immediate satisfactions in order to gain the greater but more distant ones. The fact that a person can, in effect, live in the future makes it difficult to predict in an individual case whether the learning situation is one that will motivate and be rewarding, since he may be reacting to an anticipated future situation rather than to the present one.

Another factor that makes individual prediction hazardous is the differential nature of perception and attention. Real situations have many facets, so that an individual cannot perceive all that the situation, in fact, includes. He cannot see all, he cannot hear all, he cannot sense all that could activate sense organs. In addition to the selective sensations, his past experience influences his interpretation of the sensations so that one cannot be sure, in an individual case, what he makes of the situation—that is, how he defines it. Combined with this necessary limitation to any individual's perception of complexity is the influence of selective attention. One's orientation, expectations, and purpose strongly influence what one attends to in a complex situation. This focus of attention not only makes it possible to bring to the foreground elements that are objectively weak, such as whispers in a noisy place, or objects in shadow, or a faint aroma in a garlic-scented café but also to shut out sensations that are clear and obvious to others. The importance of selective perception and attention to the learning process lies in the fact that in conscious learning the student is responding to perceived stimuli. If his perception of the situation is

different from that of the teacher, he is not in a position to learn what the teacher intended.

These ambiguities are mentioned here not merely to suggest that the notions sometimes presented of brain-washing or total conditioning are not likely to corrupt the whole species because of individuality, but primarily to suggest the importance of early childhood years in developing human beings adequate for the conditions and opportunities of tomorrow. Individual hierarchies of motives, the wide variations among individuals in the length of time they will postpone immediate gratifications for more distant rewards, individual differences in perceptions of complex phenomena and in focus of attention are influenced markedly by early childhood experience, much of it in the form of conditioned learning. Hence, the nature of early conditioning is important for the education of contemporary man.

For this task, one of the first objectives is to develop confidence in the child that he can explore new places and new behavior without losing the love and nurture of his parents. Modern man must be able to explore his environment, investigate new ideas, and gain wider experiences with men of different backgrounds. This requires confidence rather than fear, sensitivity to the positive and negative aspects of new experience to which he can respond rather than behavior guided by tradition. Too often a child is cut off from parental love when he explores the wider environment, and he then senses that he can enjoy the security of a loving home only by repressing his exploratory behavior and accepting his parent's definition of what the outer world is like and how to behave in it. With young children, avenues for exploration need to be opened up in a way that furnishes new experience where the child must cope with some disagreeable features as well as enjoy the pleasant ones. As the range and difficulty of the places he explores are increased, he learns to approach new experiences with confidence and to be guided by his own observations and interpretations rather than to accept traditional attitudes without question. This kind of early conditioning is very important for the development of a genuine world community.

A second emphasis in the early conditioning of a child is in developing faith or confidence in the capacity of each generation of men to solve their problems rather than to place this faith in the answers that have been given in the past. This confidence in working out new solutions to problems is important because the problems and the criteria for effective solutions are in continuous flux. Now, for example, many people recognize pollution as a serious problem. This was not the case 50 years ago. Furthermore, an acceptable solution to the problem of pollution today would be significantly different from what would have been acceptable in 1920.

To develop this confidence in the power of collective intelligence to deal with difficult problems, the child needs to have many examples within his observation and participation that show the world as something men are always learning more about—not one in which everything is known. He needs to see people at work on the analysis and solving of problems rather than waiting for someone else to tell them what to do. He needs to discover that knowledge is made by man and is growing and changing as man finds out new things from his experiences. Education for contemporary man is not finding ready-made answers from books but learning how to inquire, how to formulate ideas and test them, how to use his intelligence in understanding the world and himself, and in solving his problems.

The development of faith and confidence in our own human intelligence conflicts with faith in tribal gods and belief in the teachings of tradition. These latter, although often of value in giving security and reassurance to the members of the tribe that they will succeed and prevail in spite of obstacles, have a serious limitation in their emphasizing the inherent superiority of the chosen tribe against all others. They also give children a conception of a fixed world of wise men who know all the answers, thus failing to emphasize the necessity for world-wide cooperation in working out new ways of dealing constructively with world problems.

Fortunately, curiosity is characteristic of children, and their drive to find out and to explain things can be a powerful motive for conditioning them to seek to understand, to discover that answers to questions can be worked out by men, and that they themselves can develop better and better explanations as they approach problems from different perspectives and increase their own experiences with the phenomena about which they are curious. The positive reinforcement of children's efforts to understand, combined with guidance in ways of learning, can contribute strongly to building this faith. The difficulties lie in the easy way weary adults have of shutting off curiosity and the desire of parents to furnish answers to children rather than help them to push on with their inquiry.

A third center of early conditioning is concerned with the interpretation and enjoyment of human relationships. Most children are negatively conditioned, so that they expect and seek a very few elements in their relations with other human beings. They do, of course, learn to expect from parents and friends help in gratifying physical needs and opportunities to participate with limited roles in social life. But, on the negative side, they expect aggression, rebuffs, or aloofness from most of the others with whom they come in contact. By the time they are young adults, their social relationships are greatly circumscribed both in the variety of people with whom they have meaningful relations and in the range of human interaction in which they participate. Along with exploring the wider world, children need to be positively conditioned to seek out new persons from different backgrounds and to be involved in an increasingly wider range of relationships. They can participate in work as well as play in helping older people, as well as being helped by them, in listening to stories of experiences of persons from different backgrounds as well as in recounting anecdotes they think interesting. Too often, children gain from adults conceptions of what is proper, what is enjoyable, and what are the values in human relations that are entirely too limiting—especially when they are conditioned to this view throughout life. A world society requires citizens who participate with others in a wide range of situations, not because they feel it a duty but because they find satisfaction in a common life shared with others throughout the world. But to appreciate a multicultured and a multivalued society, children need to have experiences with persons who come from other backgrounds and whose hierarchies of values are different. They need help in playing various roles in their relations with others; they need help in understanding other customs and practices, other beliefs and values. They need to see parents and friends enjoying interactions with others without losing their own identities in these experiences.

The purpose of early conditioning in the area of human relationships is not to give children the belief that the people of other groups and nations are model angels wholly to be loved but rather to help them perceive as ac-

curately as they can what human beings from many backgrounds are like. They have strengths and weaknesses, characteristics to be admired and characteristics to be deplored. Most are interesting and friendly and can be helpful. But they are not all alike, and, in their variety, they have to be understood as individuals, not as stereotypes. Realism regarding men and women from different parts of the world is essential in establishing a workable world order. Early exploration of human relationships is the base on which realism can develop.

A fourth center of conditioning deals with learning to postpone immediate gratifications in order to enjoy greater but more distant rewards. Most of the problems of modern society take time to work out. Most of the skills, techniques, attitudes, understanding, and appreciations that contemporary man must acquire take a relatively long time to develop. Individuals who are unable to discipline themselves to a long span of time before their effort pays off are ill-adapted to the conditions of modern life. Hence, the development in children of the ability to postpone immediate gratifications in order to reap great rewards later is quite necessary. A child can be started with a short span of working for a desired reward, such as devoting two weeks to earn two quarters to obtain something of greater value than one quarter would have purchased had it been spent when it was earned the first week. Situations should then be developed in which there are increasingly longer spans of time during which some rewards are foregone to gain a greater one later. In this conditioning, a child is aided by periodically talking about and imagining the satisfactions he will have later and, by receiving a variety of reinforcements when he has carried through to the end, including the reward he sought, the approval of parents and friends, and additional comments and praise for the achievement.

Of course, the purpose of this program of conditioning is not to eliminate all immediate gratifications but to enable the child to choose for himself whether he will take immediate satisfactions or work for a larger and more distant reward. There are occasions when spontaneity and gaiety are enhanced by seizing the opportunities of the moment, while there are other times when such a choice would make it impossible for the individual to gain something he really values much more. He must be able to choose and to follow through on whatever choice he makes. Without early conditioning, postponing gratifications is difficult, often impossible, for him.

As parents and teachers use conditioning to help the child gain the perspectives, the attitudes, the habits, and the practices on which more flexible behavior can be developed, more and more of the purposes and techniques of conditioning should be made apparent to the child and become a matter of conscious discussion. This is necessary in order that conditioning can be controlled as far as possible by the individual and used as a technique for his own purposes rather than being a hidden weapon utilized by others to manipulate him. The objective of the conditioning that has been recommended, like the aim of all education, is to increase the range of life choices available to the individual in modern society. The four conditioning programs are suggested because they do not narrow the outlook, restrict the exploration, reduce the boundaries of social experience, or limit the individual's habits of learning to those that furnish immediate rewards. They are not designed to seal individuals into niches but to enhance their autonomy and increase their capabilities for further learning and development. Parents and teachers should point out and demonstrate that each learning program really adds to the individual's range of choice and his ability to follow the lines chosen. It opens new doors rather than closing any. In seeking learning opportunities, children and youth can be helped by understanding this basic educational purpose.

When the child understands what conditioning is, how it works, and for what kinds of learning objectives it is effective, he is able to employ conditioning for his learning goals that can be achieved in this way and to avoid conditioning himself or being conditioned when this would produce an undesirable result. For example, if he wants to develop skill in a new sport, conditioning is likely to be effective and efficient. If he desires to develop proficiency in hearing and speaking another language, he can use conditioning. On the other hand, he may note that he is being conditioned, without realizing it, into a narrowly circumscribed social and civic life, and he may then decide to develop a consciously planned program to extend his understanding of and participation in civic affairs.

Thus far, the discussion of early childhood conditioning that can provide a sound base for education emphasizing responsible choice has not raised the question of the likelihood of such a development of child rearing on a wide scale. This is very hard to predict. In the past, children have been taught to believe and act very differently. Group loyalties have been inculcated, ethnocentricism has been developed both consciously and unconsciously, children's curiosity has been stifled by many parents and teachers. Children have been taught answers rather than encouraged to carry on lifelong inquiry. Security has come from acquiescence and from remaining at home rather than from exploring and questioning. Yet, in spite of this situation, the widespread evidence of world change, social crises, and the development of international communication are making more difficult the efforts of those who would condition the young to respond to the old ways. The initial revolt is from the old to a new, rigidly conceived panacea. This, however, entails no great change in child-rearing practices. The usual political, economic, or social panacea substitutes one dream for another rather than helping children to explore experiences and to trust the evidence of experience. But even in countries where new doctrines are substituting for old ones, the awareness of the people of the relevance of experience is growing. Increases in the practice of the kind of conditioning outlined above can be anticipated because they are in harmony with the growing awareness of people in many parts of the world. But several decades seem likely to elapse before most men can feel secure without the convictions that are built around narrow group loyalties that are often divisive. The experience of minority groups in the United States as more avenues of participation are opening to them is that their sense of identity and respect can easily be lost unless undergirded by narrow loyalties and threats of aggression. Especially when the real position of a group is an intolerable one does it seek the assurance of ultimate success and ultimate victory over its real or imagined oppressors. These narrow loyalties and divisive beliefs are not likely to wither away until tribes and other groups are conscious that they are achieving and can find ample evidence for identity and respect in the real world.

The prospectus for this Conference states: "Among the options for critical examination are, for example, the development of planet-wide programs of basic education in the prehistory, history, and potentiality of human society, supplemented by exchange of students on a massive scale." This suggestion

offers great possibilities as an educational program to follow earlier stages of conditioning. At present, the schools in all nations lack authentic materials regarding the development of human society and the potential evidenced by this development. Most of the material used with children and youth is either grossly distorted myth or a narrow selection of the field of study based on ethnocentric perspectives or limited notions about the important areas of man's achievements. Furthermore, most such material fails to associate the student in seeking to understand man's condition, his aspirations, his striving, and his achievements. It leaves him untouched without having learned anything significant.

The exchange of students on a massive scale is likely to have a positive influence in developing world citizens, but the relatively brief time that a student spends abroad has, in the past, been largely occupied in activities entailing limited cooperation. Instead of the usual exchange program, a more promising option is a carefully designed work-study program in which students from various nations serve together on task forces responsible for achieving a goal recognized as important by all. This is one of the values of the Bristol Channel Rescue Program, for which the students at Atlantic College are responsible.

The youth there are from many nations. When a ship is wrecked near the college and people are thrown into the heavy seas, the work of the students in rescuing them is serious and effective cooperation is essential. In such associations, students get to understand themselves and others much more than in the usual school situation. Of course, not all international student groups can have rescue experience, but it should be possible to find hundreds of types of important tasks that can be undertaken by teams of youth in ways that furnish the invaluable learning that comes from working together under stress.

In the university years, international teams of students engaged in inquiry and problem solving in areas of great social or intellectual significance can contribute greatly to world understanding on the part of young men and women as well as accomplishing the purpose indicated in the prospectus: "No doubt a principal theme should be the growth of knowledge and the arts through freedom both to differentiate and to integrate."

The prospectus raises two other important questions: What specialized education, if any, beginning at what age, is desirable for leaders in government and politics? By what strategies can the rising generation be smoothly incorporated into adult roles without sacrificing youthful drive and inventiveness?

I shall comment on the second question first, because my response to the first builds on the second. In most highly industrialized countries, the demand for a large percentage of persons with 10 to 16 years of education has been met by supporting the continuous schooling of youth from five or six years of age to about 20 years. Typically, they are kept out of the labor force and other opportunities to participate in the adult world until their formal schooling is completed. Yet adolescents are conscious of their physical and intellectual maturity. They want tangible evidence that they are able to fill adult roles, but they are isolated in an adolescent island without any sense of significant responsible participation in the adult world.

What is needed is to open the doors of secondary school and college to the wider community and to arrange for students to spend part of their time in responsible activities, in work, in civic affairs, and in social service. The kind of cooperative education in which college students alternate quarters at work and quarters in residence has been shown to result in increased motivation to study and learn, increased personal and social maturity, and easier transition to full-time adult roles than is characteristic of typical college programs. The college employs coordinators to work with employers and students to provide for increasing complexity of work responsibilities and significant connections between the job experience and the college curriculum. Some programs of cooperative education are found in high schools, but this does not involve a large proportion of students. A wide expansion of responsible experience, like the suggestions for student exchanges, would add greatly to the positive induction of young people into the larger society.

Given such a background of second-school and college education, the specialized education for leaders in government and politics starts when the individual seriously aspires to such a role and begins to explore the possibilities through reading, observation, and interview and by utilizing the choices available to him in cooperative work, social service, and civic participation in school and college. With this background, his university specialization can be greatly strengthened through intern experiences in government and politics—locally, nationally, cross-nationally, and in international organizations like the United Nations. Assuming that he has had an international exchange experience in his youth, his plan of internship should associate him in alternating experiences in political or governmental organization within his own country and those without. The kind of planet-wide perspective required of a political leader for the future can better be attained by working in situations of more than one national perspective and also in international organizations in which no single national view is adequate.

The intern experience should be more than simply working in an organization. It should also include periodic seminar meetings in which a group of interns are able to report what they are doing, what they have observed, and what they see as problems and can discuss possible interpretations in order better to understand what is going on and to gain a sounder basis for working effectively in such agencies.

In summary, the position presented in this paper is that conditioned-response learning can be employed in early childhood training to build a disciplined base for voluntary, consciously directed learning. A combination of conditioning and a system of consciously directed learning is necessary to develop individuals adequate to meet the complex requirements of a world society and able to develop their own unique human potential.

COMMUNICATIONS—KEY TO MAN'S SELF-AWARENESS

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To understand and transform environment, to dominate himself and his condition, man requires knowledge and self-awareness. Just as verbal and visual symbolism and language, the fruit of human interaction, bring amorphous experience to structured consciousness, communications are vital in a world society for the creation of enlightened understanding and cooperation through world-wide dialogue.

Communication implies more than one-way dissemination of information, entertainment, advertising and education. It gains its full significance only when a multiplicity of points of view, of interests and aspirations, whet themselves against each other through critical confrontation. Society in rapid transformation and in dialectic conflict within the context of global interdependence is in need of channels of communication that permit a constant dialogue among separate and frequently opposing forces. Like government, media of communication become truly constructive and responsive to man's needs when they are not merely for the people but of the people and by the people.

In the space age, communications media break through the traditional fragmentation of society and vividly bring to light outdated and frustrating limitations. Human rights and social aspirations, knowledge, and information can no longer remain the monopoly of a privileged few. Broadcast signals may cross artificial boundaries of sovereign nations unhampered. A stream of communications breaks down the vertical stratification of society, and the horizontal barriers of nationalism. Here lies the promise of the future—but it is a far cry from present reality.

The topic assigned to me as a contribution to this Conference is *Communications, News and Comment*. But how may we isolate information from its cultural, social, and political context? What is news to some may well be trivia to others. What some accept as an objective reflection of reality others may consider biased distortion. What is relevant here is incidental there.

The media of mass communication—radio, television, film, the press, and the low-cost book—are the focus of our attention. But they are part of a broader communications process, technological in one dimension, interpersonal in another. Recorded media for individual or group retrieval, data transmission, and computer-assisted instruction, programmed learning and teaching machines—these are extensions of the media towards individualized use. Personal contact among neighbors and families, teachers, and students, politicians and citizens, experts and laymen—the traditional forms of human communication—retain their influence despite the growth of technology. Each level of comunication affects and modifies the other. Mass media are absorbed into interpersonal communication or made accessible at will in recorded form, while "the voice of the people" makes its impact on the media through word and demonstrative action.

This is the background against which the media exert their particular influence. We may speculate on the capacity of communications to promote the transformation of society, but such speculation is conditioned by awareness of

the restraints imposed today. In a society as highly developed as the United States, these restraints may not be as obvious as they are from a global vantage point, yet even in this country the vast gap between reality and potential poses a burning challenge.

Availability of the media is a first condition. Despite rapid growth of the media during the past decade, such large countries as India have practically no television, while elsewhere in the developing world, where up to 90 percent of the people live in rural areas, it is primarily an urban phenomenon. Similarly, the press is largely restricted in content and distribution to the cities. Radio is still the privileged medium of communication in the greater part of the world. It has a relatively low cost of production and reception, its transmissions cross natural barriers of mountains and deserts, swamps and uncharted distances, and the transistor brings it to the nonelectrified village. The flow of news is largely controlled by a few world agencies that dominate information not only across the world but also between neighboring countries and within individual nations. The modest minimum of five radio receivers, two television sets, two cinema seats, and ten copies of a daily newspaper for every 100 inhabitants is not attained in many countries; others, as in Latin America, exceed this minimum through massive reception in the cities, while the rural people remain outside the stream of information. (See tables in appendix.)

Control and structure of the media is the second factor that affects profoundly the media's ability to serve a society seized in the process of change and in need of a large stream of unbiased information and education. Subject to the constraints of commercial revenue or government subsidies, controlled by the dominant classes and political organisms of society, and responding to a popular craving for escape from the harshness of reality, the media tend to address themselves to the lowest common denominator of audience acceptance. Their concern is with the present rather than the future, because both the adult population and the interests they serve are imbued with values and ideas of the past. But in a fast-changing world, clinging to the outdated present constitutes a barrier to the future. The germs of the future thrive in minorities, social or intellectual, cultural or vocational, in youth or discontented ferment. The test of the freedom provided by the structure of the media, and thus of their ability to promote the provocative process of self-awareness, is their capacity to reflect and serve the concerns of the many minorities that are the deeper component of majority interests.

At the root of the media's inability to meet the needs of a changing world is a widespread failure to see them as essential public resources for the benefit of the whole. Harbors and means of transportation, schools and utilities, are recognized generally as basic to society. Their development, maintenance, and operation are justified in terms of national needs rather than mere self-sustaining rentability. Even though—because they are limited and require traffic control for clear-channel reception—broadcast frequencies inevitably come under public responsibility, their utilization is generally subject to other political or commercial considerations. Contests for popularity and requirements for self-support impede their most effective use. A government in a developing country may reserve to itself the monopoly of radio and television, but frequently it expects them to become sources of financial revenue rather than a *"drain,"* however useful, on public expenditures. Without a communications policy that sees the media as essential to a developing society, assures their availability for minority purposes as well as for majority demands, and frees them from con-

straints that impede the airing of challenging and controversial views, radio and television, press and film will never give their greatest potential to society.

The function of the media derives largely from their structure and financing. Governments are judged not only by the popular appeal of their leaders but by the service they render to society. Not so the media. There is a widespread tendency to justify the media and their function in the provision of entertainment and superficial information for a large public. But what is their contribution to the promotion of culture—not only of the élite, not only of the classical past, but also to the creation of new contemporary works and values? What is their function in the education of the people, from preschool child to illiterate adult, from unemployed to physician and engineer? How do the media help the disadvantaged to improve their health and ability to find employment, to raise their children so they may meet those from more affluent homes on an equal basis, to master the daily needs of their environment and participate in national and international affairs? How do the media contribute to a world society in which the youth of many countries may struggle with the same problems and seek to learn from each other, to support each other in a common venture? Do information and comment reflect these concerns, or are they confined to restricted political and social views and applied by a self-appointed élite for the dissemination of facts and opinions to an unknown and heterogeneous public?

Participation and dialogue condition the function of the media. Communication implies two-way dialogue. The dramatic frustration of modern media of mass communication resides in the technological and economic trend toward the centralization of productions disseminated nationally and throughout the world. The film maker judges his effectiveness in hard cash. But is he understood, does he respond to real needs? The television producer is rewarded with audience ratings and foreign sales. But do these express the substantive needs and views of the public?

The most significant role of the media in the contemporary world is perhaps their ability to overcome divergence and mutual ignorance among those whose cooperation is vital to survival. They may bridge the gap between scientist and layman, between decision maker and citizen, between traditionalism and orientation toward the future, between establishment and youth, between urban society and rural majority. But bridging these gaps implies two-way, not one-way, communication. It is not enough to present one side, be it dominant, progressive, or acceptable. The "other" side also has its points of view to present, its knowledge and experience and aspirations. Unless the agricultural reformer listens to the wisdom of the practical farmer, unless the scientist is able to respond to the "simple" questions posed by the citizen whose very fate depends on the impact of science, unless the politician keeps his ear to the ground, authorities, opinion leaders, and specialists tend to be rejected and eventually to become ineffective. As President Leopold Senghor of Senegal once remarked to me, when I pointed to the challenging criticism in feedback responses to rural radio programs: "I have only the alternative between dictatorship and dialogue. I must accept the dialogue, and even the 'contestation,' if dictatorship is to be avoided." Peasants and youth, racial minorities and striking workers respond to the messages of the media when they are convinced that these messages reflect themselves as well as the other side. Information and comment are more deeply meaningful and accepted when they also express the ideas of those to whom they are addressed.

Such dialogue is not easy to obtain. It implies that the media professional is as concerned with reception and utilization, with research and feedback as with program output. This has many practical implications: steps have to be taken to make the media available to the disadvantaged, through the distribution and maintenance of receivers, the stimulation of the rural press, the screening of films in areas normally excluded from commercial circuits, the coverage by broadcast signals from ground-based or satellite transmitters that reach far into the hinterland, and production of television receivers for nonelectrified areas. It also entails the organization of group reception and discussion, not merely for economic reasons but in order to enable the listener or viewer to examine critically what is presented, to decide on follow-up action where this is applicable and to respond to the media originator. The producer of educational programs learns that his efforts are more effective if there is guidance and personal supervision for the distant learner. Finally, there is need to integrate research data into production so that program output is continually modified to take account of audience impact (qualitative impact, understanding, rather than mere quantitative response). An openness of mind as well as funds, personnel, organization at the receiving end are as significant to media utilization as the quality and content of what the media have to offer.

Alienation has become a well-worn characteristic of contemporary society. We find it at every level of living. Beyond man's relationship to the industrial process of production, as stressed by Marx, alienation is equally apparent in the gulf between life at the local level and dependence on events on the other side of the globe. It emerges in the frustration of the consumer society in which mass media familiarize people with amenities far beyond their reach. It arises out of the contradictions of state-bound or nation-bound legislation and worldwide involvement. It is evident in the disparity between the individual needs of the student and the indiscriminate massive offerings of education and training.

Because alienation is a basic factor of reality, because man lives simultaneously in superimposed circles of involvement, it would be illusory to expect communications, much less the mass media alone, to eliminate the schizophrenia of existence. But communications can make a vital contribution toward alleviating at least some of the most disturbing disparities.

Fortunately, the modern trends of communications technology permit far greater adaptation to needs than was hitherto possible. On the one hand, there is space communication, which goes beyond the confines of national sovereignty. On the other, we witness ever greater localization. Local broadcasts, closed-circuit transmissions, and individual or group access to recorded programs permit adaptation to the special needs of groups and individuals. The future lies in a systems approach that combines all forms of origination, relay, and reception with the total process of communication and instruction. Yet reality around the world is far from this objective—we still live in an era when not even national coverage by only one of the media is attained in many parts of the globe.

Perspectives of Public Policy

How may the future be explored beyond the limitations of the present? How may communications open up the broad flow of information and comment,

the dialogue and flourishing of man in world society? Only far-sighted public policy can lead the way.

Basic to such a policy is the recognition of the public nature of media of communication. Mass media are of public concern because they manifest themselves in the market place, profoundly affecting the individual in his environment. Their importance to political life is so obvious that no society can afford to ignore their role. They penetrate deeply into the home and the school, the place of work and leisure. This is particularly true of radio and television, which use publicly owned frequencies and are, more than any other medium, accessible to all, literate and illiterate, young and old, poor and affluent.

Hence, broadcasting cannot be the privileged domain of private enterprise or government policies, of entertainment industries or educational institutions. At first sight, this may not be clear to the owner of a broadcasting station, the producer of programs, the listener or the viewer. Owners may see only their commercial interests. Producers may be concerned purely with personal expression or popular appeal, with slick performance or sensationalism, with educational content or political propaganda. As for the audience, it generally does not realize that the act of receiving and selecting broadcast programs, purchasing a newspaper or cinema ticket is in itself a public action rather than mere satisfaction of personal desires. Its action is registered in revenues, tests, and polls that are communicated to the highest economic and political authorities.

Power of such magnitude cannot escape public concern, for the essence of a stable society is proper regulation of its forces so that they may not encroach excessively on either public interest or private lives. This is recognized elsewhere. Trade and industry are regulated to protect the entrepreneur and the consumer. Working conditions and health standards are no longer left to supply and demand or in the sole care of the family. In the pursuit of education, society has long recognized the impossibility of relying solely on the personal quest for learning. However essential the individual's eagerness to seek education, society cannot flourish unless conditions are propitious to the individual, because the general level of education is an essential factor in the development of modern civilization. Ever since the introduction of compulsory education and large-scale public financing of schools at all levels, it has generally been accepted that education is a public necessity that overrides individual choice and immediate cost-benefit considerations. The same public approach applies to the media of communication.

Yet it would be a fallacy to see the mass media solely as agents of society and particularly of governments. Their very nature places them at the watershed between public and private interests. They cannot have mass appeal without some personal initiative, if only the decision to buy a receiver or a newspaper. Even the most rigidly controlled broadcasting organization cannot get its message across unless people own sets and tune into them. And they cannot be "of" the people unless they assure freedom of expression and views.

Access to the media determines not only their general impact but their financial health as well. Audience size influences revenue. Even educational broadcasting depends on the willingness of schools and communities to acquire receivers and use them regularly. This they will not do unless they are attracted to the media and convinced of their ability to educate. Media are always forced to blend public service with public appeal.

In the era of space communications, radio and television are not only national but world-wide resources, part of the fabric of world society. But their

structure is still determined by national sovereignties. Their use for purposes that go beyond national considerations is merely incidental. Although they are resources of all mankind, numerous countries barely begin to realize at the national level their essentially public nature and the manifold purposes to which they may be applied. The present structures of broadcasting seem as ill-suited to a dynamic and closely interwoven world, to the promotion of a sense of world citizenship, as unrestricted sovereignty and the inequities of economic development.

Hence the two prerequisites for the future: universal access to the media and structures to safeguard their independence and public service.

Universal access has first of all a technical dimension. It includes coverage by broadcast signals from ground-based or space transmitters that make good-quality radio and television reception possible throughout the vast rural areas of developing countries and across all regions of the world. It includes access to local, national, and world-wide broadcasts, to open- and closed-circuit transmissions, to live programs, and to recorded productions that can be repeated at will for use by communities, schools, and individual students. In short, universal access means first of all the availability of all facilities so that every opportunity may be explored for communication through sound, picture, or printed page.

Universal access has, however, more than technical implications. Without the capacity of the people to make use of the media for their own benefit, mere availability is incidental. What use is the press if people are illiterate? What is the benefit of education programs without opportunities for suitable study and follow-up work? What value have programs for the promotion of agriculture, health, or family planning if the community is not prepared to use them intelligently and lacks the facilities to apply the message received?

Universal access finally means, with equal force, the ability of the citizen to express himself through the media and to have access to studio and microphone, to printed page and cinema screen. The professional fulfils his true function of communicator when he is above all a mediator. When he records his programs in the villages so peasants may speak their minds, when he lends his mastery of the technique to bring to the screen the talent of dramatic groups and youth ensembles, of school children and specialists, he helps to take the media out of the hands of the monopolists and renders them to the people.

Legal and financial structures that provide the greatest opportunities for creative freedom and public service, for independence and objectivity, for minority interests as well as mass appeal are the second prerequisite. How delicate is the balance between the individual creativeness of the producer and the public nature of his work, between the initiatives of the professional and the multiple aspirations of the people, between centralized direction—diffusion from the top—and response to the interests and desires of the audience! Just as checks and balances are the basis of democratic government, they are also essential to the management of mass media of communication.

Far be it from me to suggest any single form of organization, since the dynamic evolution of each society poses its own characteristic issues. But, in one form or another, the issue is posed in every society. Broadcasting reaches out toward world communication at a time when world-wide interdependence exists in fact but has not found adequate expression in political structures that go beyond the limitations of national sovereignty. Yet there is no doubt that the pace of technology, the aspirations of the people toward ever greater participation in public affairs, and the intertwining of man's destinies are creat-

ing a world society that impels a constant search for new ways in which the media of communication may be organized with a view to the future.

Achievement of these two prerequisites will open the gates to meaningful use of the media. Information and comment, education and cultural expression, attain their full value when they reflect the gamut of local problems and world-wide issues. Only in freedom can the media contribute to man's self-expression and awareness, to his education and ability to cope with the pressures of social and physical environment. Hence the need for the greatest variety of channels and opinions, of form and content.

Such *variety* cannot be left to the initiative of a self-sufficient élite, however well-meaning. Constant feedback from the audience of the media, feed-in to the media from the people themselves, are essential for clarifying dialogue. This dimension is little explored today in running mass communications. Its forms are numerous. To mention only some of them:

—Numerous simultaneous channels of communication—local, national, and worldwide—express a multiplicity of points of view and offer a great variety of content to choose from;

—Programs are "field-based" rather than studio-produced;

—The audience responds to programs with comment and criticism that is answered in turn on public airwaves;

—Children and adults are led to evaluate critically media output and to develop a sense of discrimination that in turn influences the nature of the media itself;

—Producers meet their public in frank discussion so they may sense the impact of their creation rather than be guided only by the reaction of professional colleagues;

—Audience response and understanding (or lack of understanding) is fed into production through careful research that takes account of not only quantitative appeal but qualitative appreciation;

—There is direct media exchange between communities of the most diverse origins—young people produce their own films and send them across the world, local stations engage in dialogue over vast distances on the air, urban and rural citizens confront each other, and nationals of one country examine common issues with other nationals beyond their borders who differ profoundly in economic interests and political opinions.

Under such conditions, information and comment will flow widely and stir both controversy and cooperation. There is evident danger in such a wide-open media policy. But danger and risk are of the essence in life and fast-changing social conditions. The wisdom of democracy lies in its realistic recognition that inevitable conflict is better openly argued than denied to the point at which utter frustration and passivity, or explosion and revolution are the only alternatives. Media that reflect both conflict and consensus fight danger by living with it. It may be dangerous to air controversy, but even more fateful to deny it.

What is true at the national level is even more valid internationally, for it is international conflict that threatens the existence of man. As technology transcends national boundaries in the era of space communications, there is an inevitable urge toward new forms of organization that live up to the challenge

and opportunities of world society. As Arthur Clarke has pointed out, large countries like the United States would never have achieved their unity had it not been for progress in communications—the railroad and the telegraph. "Before those inventions existed, it was impossible to have a United States of America. Afterwards, it was impossible *not* to have it. . . . Whether we like it or not—and certainly many people won't like it—we are seeing the next step in this process. History is repeating itself one turn higher on the spiral. What the railroad and the telegraph did to continental areas hundreds of years ago, the jet plane and the communications satellite will soon be doing to the whole world." [a]

This world will require *a new organization of the communications media so they may serve the whole of mankind*, a form of world communication to supplement others that exist, and will continue to exist, at the national and local level. The flow of information and comment, the dialogue between divergent forces, the spread of education and cultural crossfertilization call for productions conceived in content and form not only from a national but also from a universal point of view. Eurovision and Intervision, the worldwide relay of television programs from the Olympic Games or from the moon are first steps in this direction. But they suffer from a double limitation: they are subject to agreements between independent national broadcasting organizations, and they are centered largely around special events of a more or less spectacular nature. Yet technology and global interdependence make it both possible and urgent to envisage continuous programming for a world audience.

Because the same television image may be accompanied in space transmissions by different sound tracks, language differences are no longer insuperable obstacles to the widespread comprehension of such programs. A beginning might be made with education. As Clarke put it: "I do not think ideological considerations play much part in the teaching of mathematics, chemistry, or biology—at least on the elementary level, though I must admit that some small cults still object to the doctrine that the Earth is round." Similarly, specialists at the universities, engineers and doctors, agriculturists and architects seek information, training, dialogue, wherever they live. But because much of education is still nation-bound in structure and content in an effort to create nationhood out of linguistic and tribal allegiances, it is only a limited pacemaker for a broader approach. Other initiatives will come from the cultural fields and may eventually cover the entire range of programs from news to sports and entertainment.

Radio and television signals broadcast from communications satellites may soon be captured by individual communities without passing through national relay networks, and the prospect of direct broadcasting to home receivers comes closer within the next decade or two. Under these circumstances, there is danger that a few powerful stations may blanket the world without concern for the aspirations of receiving countries. Nor will it any longer be possible to entrust programming for a world audience only to a pooling of national outputs. The United Nations and its specialized agencies may seem suited to take over the task. But they, too, are intergovernmental organizations subject to the limitations imposed by their sovereign member states.

Inevitably, and painfully, public policy will strive toward *world-wide public*

[a] *Beyond Babel: The Century of the Communications Satellite*, Arthur C. Clarke, address to the Unesco Space Communications Conference, Paris, 2–9 December, 1969)

broadcasting. At this stage, it is not possible to define the legal, financial, or organizational structure of what may eventually become one or more Regional or World Public Broadcasting Corporations. What seems certain is that this is what the future holds. From hesitant beginnings centered around outstanding events or specialized fields of training, from initiatives undertaken cooperatively by professional organizations and educational administrations still rooted in their national structures and traditions, the way will lead toward a new concept in which programs are conceived from the start by an international team for a multinational public and are activated through continuous feedback and participation from audiences, wherever they are.

This perspective may seem startling, almost unacceptable, since national audiences are conditioned to prefer programs and publications of their own country, at least as far as broadcasting and the press are concerned. But, in fact, the average cinema and television fare in most countries shows a striking similarity, since a few powerful production centers dominate the world. In Algeria, only 6% of all television programs are produced within the country. Television in Thailand is so flooded by foreign programs that the English sound track of synchronized films is broadcast regularly on FM radio for those who prefer the original version. And even where programs are not directly imported, their formula and style are frequently patterned on foreign examples, as they are, for instance, in most commercial stations of Latin America. National protectionism cannot resist foreign pressures because the financial and artistic resources of most countries are unable to compete on an equal footing. Unquestionably, there is an urgent need to foster programs that are adapted to the cultural and educational needs of each country, that respond to the problems and needs of the people, not only at the national but also at the local level. But at the same time there is need for programs that respond to common values and are created through the true cooperation of talent from many countries.

Because world society is a reality, a sense of world citizenship is latent everywhere. In countries divided by linguistic, regional, or tribal differences, broadcasting is a force for national unity. May it not also become a force for a sense of belonging to mankind in a world dangerously divided and in conflict?

Public broadcasting conceived from a supranational point of view and geared toward cultural values or real problems shared by many countries may make it possible for man to live and think at the scale of his global existence, just as data storage and exchange, archives and ecological information, will be accessible to all. Such a global comunications system will be no substitute for more narrowly confined communications. On the contrary, simultaneously we shall see ever-greater localization and individualization of information and learning, dialogue and participation, so that man may eventually reconcile his disparate existence and unintegrated involvement in family and community, in tribal and linguistic, national and world society.

Accelerated change is the root characteristic of our era. Incapacity to be aware of the forces of change and to adjust concepts and practices to the demands of reality in transformation is a primary cause of conflict and frustration. How may man be prepared to live with change without loss of his inner security and stability? This is the challenge to education and communication, to ideological concepts and pragmatic policies, a challenge posed to each individual community and to world society at large. Only frank recognition of hard realities, however unpopular and unacceptable they may appear, can open the way. Self-awareness on the national and global scale through communications freed from outdated shackles is vital to the future.

APPENDIX

TABLE I

PRESS DAILY NEWSPAPER

Area	1960 No.	1960 Circulation (in thousands)	1960 Per 100 inhab.	1967 * No.	1967 * Circulation (in thousands)	1967 * Per 100 inhab.
World		221,030			282,670	
Africa	153	1,330	1.3	158	1,440	1.4
N. America	2103	63,350	11.4	2145	66,600	11.6
S. America	707	5,540	8.1	640	4,820	5.2
Asia (excl. U.S.S.R., incl. Japan)	1550	46,200	9.5	1091	62,680	14
Asia (excl. U.S.S.R. and Japan)	1400	9,160		919	15,130	
Europe	1037	63,140	21	1052	72,250	22
Oceania	111	4,600	15	110	5,320	16
U.S.S.R.	457	36,870	17	616	69,560	30

* Figures in this table refer only to countries where comparable figures were available in 1960. The total picture for 1967 is as follows:

Daily Newspapers

Area	No.	Circulation (in thousands)	Per 100 inhabitants
World	7,980	359,000	10.5
Africa	220	3,600	1.1
North America	2,190	72,600	23.8
South America	720	11,200	6.5
Asia	2,250	80,200	4.2
Europe	1,860	116,700	25.8
Oceania	120	5,300	29.6
U.S.S.R.	616	69,600	29.5

RADIO

I. Transmitters

Area	1959/60 Total	1959/60 per 100 inhab.	1967/68 † Total	1967/68 † per 100 inhab.
World	12,180		18,390	
Africa	320		520	
N. America	5,610		8,040	
S. America	1,870		2,260	
Asia (excl. U.S.S.R., incl. Japan	1,140		2,270	
Asia (excl. U.S.S.R. and Japan)	780		1,620	
Europe	2,590		4,590	
Oceania	240		300	
U.S.S.R.	410		[410] (1959)	

II. Receivers

Area	1959/60 (in thousands) Total	1959/60 per 100 inhab.	1967/68 † (in thousands) Total	1967/68 † per 100 inhab.
World	352,080		588,670	
Africa	2,760	2.2	5,970	5
N. America	182,050	21.8	309,280	32
S. America	7,730	16	13,740	22
Asia (excl. U.S.S.R. incl. Japan				
Asia excl. U.S.S.R. and Japan	20,280	4.3	49,140	15
Europe	92,950	22	127,240	27
Oceania	2,320	8.6	2,600	11.4
U.S.S.R.	44,000	20.5	80,700	34.3

† Figures in this table refer only to countries where comparable figures were available in 1960. The *total picture for 1967/68* is as follows:

I. Transmitters

Area	1967/68 Total
World	18,500
Africa	600
North America	8,060
South America	2,260
Asia	2,270
Europe	4,590
Oceania	300
U.S.S.R.	[400]
	1959

II. Receivers

Area	1967/68 Total (in thousands)	1967/68 Per 100 inhab.
World	634,000	18.5
Africa	14,500	4.4
North America	312,000	102.3
South America	26,300	15.1
Asia	70,000	3.7
Europe	126,000	28.0
Oceania	3,800	21.0
U.S.S.R.	80,700	34.2

Cinema Seats (Fixed Cinemas)

Area	1959/60 Total seating capacity (thousands)	1967/68 ‡ Total seating capacity (thousands)	1967/68 ‡ Seats per 100 inhabitants
World	55,950	63,250	
Africa	670	880	1.3
N. America	13,190	9,180	4.0
S. America	3,860	4,920	5.4
Asia (excl. U.S.S.R. incl. Japan)	8,450	9,230	2.4
Asia (excl. U.S.S.R. and Japan)	5,320	6,930	2.5
Europe	21,590	23,660	6.1
Oceania	1,000	1,000	5.7
U.S.S.R.	7,190	[7,190] (1960 figures)	...

‡ *Note:* Figures in this table refer only to countries where comparable figures were available for 1960. The *total picture for 1967/68* is as follows:

Area	1967/68 Total seating capacity (in thousands)
World	75,800 §
Africa	1,700
N. America	12,000
S. America	5,000
Asia	11,100
Europe	26,000
Oceania	1,000
U.S.S.R.	19,000 §

§ Estimation.

TELEVISION

	1959/60 Total	1959/60 per 100 inhabitants	1967/68 ¶ Total	1967/68 ¶ per 100 inhabitants
I. Transmitters				
World	2,340		11,320	
Africa	22		93	
N. America	750		3,163	
S. America	80		160	
Asia (excl. U.S.S.R. incl. Japan)	160		1,831	
(excl. U.S.S.R. and Japan)	33		144	
Europe	1,143		5,043	
Oceania	17		140	
U.S.S.R.	169		890	

Television (cont.)

	1959/60		1967/68 ¶	
	Total (in thousands)	per 100 inhabitants	Total (in thousands)	per 100 inhabitants
II. Receivers				
World	97,750		204,140	
Africa	70	0.2	280	0.6
N. America	56,820	7	80,630	12
S. America	1,840	0.9	5,200	3
Asia (excl. U.S.S.R. incl. Japan)	6,960	1	20,850	4.5
(excl. U.S.S.R. and Japan)	100	0.2	840	2
Europe	26,140	4.5	71,680	15
Oceania	1,120 ‖	5 ‖	2,800 ‖	20 ‖
U.S.S.R.	4,800	2	22,700	10

¶ Figures in this table refer only to countries where comparable figures were available for 1960. The *total picture for 1967/68* is as follows:

‖ These figures are not truly representative for the region—being based on information submitted mainly by Australia and New Zealand.

I. Transmitters	1967/68
Area	Total
World	11,300
Africa	97
N. America	3,150
S. America	160
Asia	1,825
Europe	5,045
Oceania	140
U.S.S.R.	890

	1967/68	
II. Receivers Area	Total (in thousands)	Per 100 inhabitants
World	214,000	6.3
Africa	770	0.2
N. America	87,000	28.5
S. America	6,600	4.0
Asia	22,100	1.2
Europe	71,700	15.9
Oceania	3,100	17.1
U.S.S.R.	22,700	9.6

ANTHROPOLOGY IN 1970

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I

Anthropology as the science of man has manifested an extraordinary number of changes of direction and emphasis since it began to emerge as a unified science in the early quarter of the 20th century—in the U.S. in the work of Boas, in the United Kingdom under the leadership of Rivers and Haddon, in France in the work of Durkheim and Mauss, and in Germany and Austria with the work of Graebner, Ratzel Frobenius and Father Schmidt. The number of types of enquiry included differed from one country to another in the extent to which paleontology, prehistory, archaeology, the comparative anatomy and physiology of living man, comparative study of primate or mammalian behavior, and theories of evolution were blended or combined uneasily with studies of the forms of social, political and economic organization. The study of earlier historical periods combined with that of isolated folk cultures was important on the continent, while in the United States anthropology became primarily the study of the language, archaeology and contemporary behavior of the surviving nonliterate peoples of the world. Analysis of the customs and languages of peoples for whom we had documentary materials of any kind was considered the concern of other disciplines. Thus, the study of the great civilizations of China, India and the Middle East were treated as the purview of specialists, and the economic and social behavior of members of contemporary European or Asian cultures was regarded as the subject matter of sociologists, economists, social psychologists, students of human growth and development, specialists in contemporary linguistic theory, or students of technical development.

Crossover points came in the field of applied anthropology, when it was necessary for purposes of government, war or directed social change to consider both primitive and modern economic or educational systems, or systems of contrasting values, or when questions of race and disease brought the characteristic disease picture of a modern population into line with an understanding of the evolutionary value of such a condition as sickle cell anemia—protective in its heterozygotic form for populations exposed to malaria, dysfunctional when malaria is brought under control.

Nevertheless, in spite of such crossovers between disciplines, there has been a strong tendency for anthropology to do intensive work with many preliterate peoples and to leave those cultures in which writing is an outstanding characteristic to another set of specialists—historians, economists, sociologists, demographers, etc. This has been particularly true when it came to specialized methods of research. Although, for example, the historian was trained in the use of documents and inscriptions, the archaeologist in the combination of archaeological remains and inscriptions and documents, the sociologist and economist in the analysis of complex written or tabulated data, the anthropologist maintained and maintains a closer relationship to all the materials that provide

him with the basis of his knowledge and theories. He studies those cultures that can be approached only through a first-hand study of living members, specializes in languages that he is the first to reduce to written form, excavates in fields in which there are essentially no decipherable records, measures and somatotypes living men, and includes, today, the study of primates in the wild. His techniques remain essentially direct firsthand observation, whether recorded with pencil and paper, tape recorders, cameras, or the apparatus of videotaping. When he explores modern societies, although he may invoke documentary materials, statistical tables, and laboratory experiments, his methods remain essentially the same—observation of the living scene, the treatment of written materials such as historical records of party congresses or movie scripts as if they were records of living behavior, so that he can analyze them with the help of native informants as he would had he been present as an observer. He does not, as a rule, make any attempt to master the techniques of the human sciences that rely on documentary or laboratory techniuqes. If he wishes to use them, in working on modern problems, he must either work in teams with numbers of other disciplines or rely on consultation and secondary sources.

There has been a continuing interest in dealing with wholes: with mankind as a species, the single hominid species now existing on this planet, with many variations in climatic and breeding conditions, but still essentially one species, exhibiting complete intraspecies fertility and hybridization between varieties as a source of strength; with human history and prehistory as one adventure extending over hundreds of thousands of years as early hominids spread out and human cultures evolved by virtue of a series of biological changes—the opposable thumb, erect posture, changes in the brain, neotony—and by virtue of cultural inventions—language, tool using, use of fire, forms of social organization, horticulture—so that man's earliest beginnings can be systematically related to his contemporary history. Language also is treated as having arisen in the course of human history. When comparative studies of primates are admitted, it is again to see development of species-characteristic behavior within groups of related forms. Any contemporary observation, any recovery of the past through the paleontological or archaeological record, is fitted implicitly into this entire scheme, man developing on this planet, spreading out, inventing, borrowing, earlier forms being superseded by more elaborate forms of social organization, religion and technology developing in parallel with the growth of cities and an increasing population size. Essentially there is no observation of any kind of behavior or record of behavior, from the shape of the human jawbone and the contour of a hand axe to the form of a gesture or the way of holding a knife or a pen, that cannot be fitted into this whole.

In his search for data, for bodies of materials that can provide a growing corpus on which theory and understanding can be based, the anthropologist has, therefore, sought for wholes that were most manageable and that could be subjected to the most complete analysis—small tribes, unwritten languages, small communities, the archaeological sequences of small isolated peoples, such as the Eskimo or the American Indians of the Southwest—where he has sufficient command of his material to see the interrelationships of all the parts. In the objection to fragmentation of his subject matter, he stands with the vanishing school of historians and classical scholars who attempted to master all of the existing material on a period in history, with those naturalists who were specialists in all of the fauna and flora of small islands, and with those students of personality who are willing to give hundreds of hours to the exploration of the psychological experiences of a few patients or subjects.

These emphases are particularly apparent in the work of Franz Boas, who recurrently tackled new aspects of the diverse subject matters of anthropology, either himself or by encouraging his students to make in-depth probes into new places. Each probe, whether it was study of the design of Eskimo needle cases or the shift in idiolects among different households within the language spoken by a small Northwest Coast Indian community, was as thorough as possible. In the pursuit of such detailed, controlled, particular data, the whole was not lost sight of, although further data that would be needed to connect the results of these single in-depth studies would not be collected for many years. Comparably, physical anthropologists interested in early man have worked with single fragments—a jawbone or a few teeth—using them as clues to a whole skeleton, a whole that could be conceptualized before it was known. New data would alter many of the factual conclusions, change the temporal horizons, alter our ideas as to where man originated, how he wandered and differentiated, where an invention was made, a song first sung. But the grand design remained to give form to the persistent search.

In the face of the growing fragmentation of both the sciences and the humanities, and as more materials became available for the exercise of scholarship, it has been increasingly difficult to maintain this integrated approach to man, to include man's biological history as well as his cultural and social history within one area of study. Periodically, we attempt to draw together, to reassert, in conference or curriculum, the inclusiveness of our subject matter, and to define the way in which our discipline's specialized conclusions relate to the whole of mankind. Such integration takes different forms: a real, as in the series of International Congresses of the Americanists drawing together all those who studied the early cultures of the Americas; international, as in the International Congersses of Anthropological and Ethnological Sciences, where European folklorists and etymologists find themselves jostling elbows with English and American students of aboriginal Australians and New Guinea cultures and languages. Thus, the difference in emphasis in different countries provides new levels of inclusiveness out of new forms of specialization peculiar to different areas of the world. More recently Japanese, Chinese, and Indian anthropologists have been making their specific contributions to such specializations, as are the scientists and scholars of the U.S.S.R. and the other countries of Eastern Europe. Scandinavia has maintained a consistent tradition of specialized interest in early European culture and in the Eskimo. Countries have differed both in their own traditional area of concentration and in the subject matter, partly because of the archaeological sites, primitive or tribal peoples, or exotic peoples to which they have the readiest access. Thus, it is as a former colonial power with a rich background in Indonesian culture that Netherlanders contribute to studies of jurisprudence, or the Japanese to the early history of their island possessions. Integration has also been provided by such attempts as the 1952 Wenner-Gren Foundation International Symposium on Anthropology, which reaffirmed the unity of the historical subject matter and introduced new areas of interest and specialization.

So also the Human Relations Area Files and the system of classification of cultures developed in Paris provide new ways in which diverse subject matters, many geographical areas of the world, and new methods of research—all essential to the wholeness of the subject—can be brought into new relationships. Anthropology, more than any other discipline except geography itself, is informed and extended by materials drawn from different geographical settings, by data on man's body and man's culture that are closely related to the climate

in which he has lived, the nature of the soil he has tilled, the forests in which he has hunted, the materials and terrain that have guided and shaped his houses and towns and cities, and the landscape and weather that have given form to his cosmologies. As each new nation enters the modern world and as its members engage in the study of the human sciences, each group brings with it a special, historically given ingredient, without which the subject as a whole would be different and less complete. Mexico, through the work of both Mexican anthropologists and anthropologists from other countries, is an outstanding example. Each new country, like each new archaeological find that opens up yet another civilization, or each study of a different primate group that opens up new psychological possibilities, changes the shape of the developing whole, a science of man that parallels, reflects on and reflexively influences man's fate on a planet that is rapidly becoming known in all its furthest reaches.

At any given moment in history, the relevance of a particular anthropologist's work, or that of a particular anthropological school to the concerns of the other sciences or of the informed and questing laymen, varies greatly. One may encounter in the course of an afternoon at a large conference specialists on the diffusion of some design or minute object of decoration, on the problems of linguistic form, on the archaeology of a continent, the present social condition of a new nation, or the future of this planet. Governmental agencies, intent on finding advisors on large and small policies, often seek out anthropologists and find themselves inexplicably saddled with an anthropologist whose level of interest is quite different from their needs. We are bound as anthropologists to each other by a common set of assumptions about the unity of mankind, the nature of man's history, the interrelatedness of human culture, the nature of learning, of cultural transmission and cultural borrowing, and the relevance of the smallest detail to the largest whole. But this is not always immediately apparent to those who integrate ideas in quite other ways.

II

In this paper I shall address myself to developments in anthropology between the Wenner-Gren Symposium in 1952, which was international and inclusive, and the present time. The end of World War II saw a very rapid growth of interest in anthropology. Academic departments proliferated, research funds became available, purposeful technological change posed new practical problems, just as the war had posed the problems of studies of culture at a distance, and there was also recognition of the need to analyze the cultures of modern industrialized societies as well as primitive and exotic ones. But the 1952 conference, although it was called international and included a few Asian delegates, was still, in its published form, primarily Euro-American in representation.

So a first significant development has been the inclusion of Asian anthropologists and renewed communication with the Russian anthropologists, particularly at the Fifth International Ethnological Congress in Philadelphia, 1956, the meeting of the same Congress in Moscow in 1964 and a later Wenner-Gren conference in 1968, which attempted to bring together representatives of different countries to complete a statement of what each national school could contribute.

Parallel to these conferences were the Pacific Science Conferences, which brought together anthropologists with circum-Pacific interests, and a wider

interdisciplinary representation from the biological sciences, especially those interested in ecology.

The International Biological Program, focusing on parallel enquiry into issues that needed to be studied simultaneously and on the concentration on vanishing natural situations, has also brought biologists and anthropologists close together; the UNESCO Conference on Biology as History, held in Chichen Itzá in January, 1969, and the search for optimal solutions rather than for the maximizing of single variables, which is a major contribution of biology to contemporary thought, and combined the anthropological emphasis on functional wholes and cultural relativity with complex, multidimensional models of biology.

It is possible, then, to say that anthropology can make significant contributions to the unification of thought as the specific contributions of different major cultures are made conscious through anthropological forms of cultural awareness, to the unification of the sciences and humanities and policy sciences by providing a basis from which the more specialized disciplines can take off, and to the development of a planetary ecological model that includes man by extrapolation from an approach that includes every aspect of small and self-contained societies. The use of macro-approaches, in which former work on preliterate peoples, unwritten languages, and small inbreeding groups, can be used as models for meeting planetary problems, complements the contemporary search among anthropologists for small units that will facilitate crosscultural comparison in which mathematical methods and computers can be used. Anthropologists have been preoccupied for the last 70 years with the problem of adapting a science based on observations *in vivo* and dependent on historical circumstance rather than experiments *in vitro*, adapted to the demands and methods of experimental science. There have been a variety of premature attempts at codification of data too various to sustain the coding, and at gross statistical methods that have yielded only gross results, often followed by reactive returns to more humanistic, less precise, methods of description. The advent of the new technologies of recording—tape, film, videotape, and oscillographic and sonographic techniques, etc.—has gradually made it possible to record human behavior in ways that are relatively independent of individual intervention. And the appreciation of the relationship between the individual researcher's integration, the enormous quantities of minute observations, and the capacities of computers has made possible new approaches to the problems of quantification of such extremely complex data. Prior to the development of recording and computers, we were dependent on the education of individuals who could deal with these minutiae and who, if exposed to different cultures or periods, sequentially, could produce viable hypotheses. The size of the communities with which anthropologists dealt, the fragility of systems that had already begun to disintegrate under contact, the brief duration of the periods of observation, and the coincidence in life span of the anthropologist and that of his human subjects, all militated against the assemblage of data with sufficiently long runs and large enough samples for traditional types of quantitative analysis.

Two developments, in addition to the development of adequate forms of instrumentation, have made enormous advances possible. One is the conceptualization of two methods of analysis: one *etic*, that is the use of crossculturally valid units—as phonetics—in which the particularities of any cultural system can be analyzed for descriptive and comparative purposes; and the other *emic*, in which the distinctive historical style of a culture can be defined in its uniqueness, by using etic units for translation into crosscultural comparabilities. This

overall methodology has been supplemented by a number of other methods developed for the intensive microanalysis of small groups and complex materials, like cluster analysis profiles and factor analysis, which have yielded impressive results in the study of cantometrics and choreometrics and made it possible to establish a world picture of man's behavior in greater depth than we have ever been able to do before. The concept of the *idioverse*, each precisely specified individual version of a set of cultural constructs, can be expanded into a large number of sets to deal with the hitherto perplexing problem of how to relate the individual to society through the medium of differentially shared cultural constructs.

Systematic analysis of aspects of human cultural behavior—paralinguistic, kinesic, proxemic, interaction as measured by time—relationships between actors and something acted upon—is beginning to yield useful units, *kines, proxemes, actons*, or computerized methods of parallel analysis, as in the machine analysis of the Chapple Interaction Chronograph. As more of these units are identified, we come closer to methods that will be suitable for the rapid analysis of small samples of complex behavior, as well as for handling the enormous amounts of information made available by modern methods of recording and made necessary by the size and complexity of the world's population.

It is also significant that the integrating tasks performed by single historians, single scientific innovators and single anthropologists in the past are now becoming impossible in today's world for two reasons: one, today's young people, reared within a set of fragmented, internally inconsistent, multimedia bombardments from every part of the globe and every school of thought, are currently imperfect human instruments to perform such integration; and two, the corpus of observations itself is too massive and complex to be handled by any single human brain. Only methods of observation, codification and analysis that call on modern recording and machine analysis have any hope of making a massive contribution to the solution of today's problems.

III

Anthropology has passed through successive periods of cooperation with the other human sciences. In its earliest period it provided materials for speculative constructs about early man and early cultures. This was followed by a period of purposive correction of culturally limited hypotheses about such matters as stages in human development, the nature of human perception, inevitable sequences of economic or political behavior, and linkages between different aspects of culture, the laws of memory, or the nature of thought. This corrective phase, which lasted substantially until World War II, was followed by a third phase, in which anthropological research began to generate hypotheses about human behavior that were not primarily reactive to earlier, more culturally limited theories. A fourth phase is now developing, in which it is possible to draw on anthropological research or to construct new research that will generate not merely hypotheses about human behavior but also new models for culture building in the future, new political, economic, and social forms.

The addition of each new function has not, however, meant that former functions were superseded. Speculation—on the basis of new knowledge of early precursors of man and early forms of man, and contemporary studies of primates—still will make a substantial contribution to our handling of contemporary problems. The study of various contemporary primitive forms of self-identification, warfare, and territoriality provides a necessary and useful corrective to hypotheses about the innate nature of human aggression, or the limits to human crowding, or the limits to the exercises of human intelligence. Experience of different forms of perception and cognition widen our view of the different kinds of human intelligence available and unused or distorted or destroyed within our contemporary forms of civilization. All of these contribute to the design of a world in which the most accurate and extensive estimate of human capacities that we can produce is essential to the success of cultural building.

Unlike the present style within which the natural sciences are organized, where the past is treated as a series of discarded and irrelevant paradigms, anthropology, dealing as it does with precious records, the partial, unrepeatable fragments of man's behavior, must continue to include and use the earliest findings as well as the most recent and to return over and over again to the same materials as new methods of analysis and new scientific formulations become available. Because anthropology deals articulately with cultural change, it should be, and sometimes is, easier to include in new structures the relationships between past theory and past data collected within the theoretical structure than it is in sciences where culture change is not a substantive part of the subject.

Such relationships are illustrated by the extent to which anthropological materials—by their very nature unreplicable because any culture event simple enough to be replicated exactly yields too little information—can nevertheless function as experiments. If adequately recorded by the new technologies, the same event can be reanalyzed many times in many different frames of reference. Such carefully recorded complex events not only function as experiments but, just because they were collected without any infusion of a current paradigm, provide a continuous form of correction of the extravagances of any fashionable point of view. We have found that it is useful to take photographs in depth, so that the behavior of individuals in the background on which the photographer did not focus can be used as a corrective for the interpretation of the behavior on which he did focus, with increasing degrees of hypothesis formulation during the course of a long field trip. In the same way, earlier work can be used as background correctives for current, focused research.

IV

The uses of anthropology as one of the disciplines that, in combination, must provide us with solutions of worldwide problems are, at present, seriously compromised by circumstances that formerly constituted one of its major strengths. In the face of chauvinistic theories of national, racial or religious superiorities or inferiorities, anthropology has depended for the very heart of its principle paradigm—the concept of culture—on recognition of the psychic unity of mankind and the right of respect to all human cultures. This has meant that the anthropologist has based his research on collaboration; informants have been trusted collaborators, not subjects or objects. Subterfuge and the use of deception, of stooges, of falsification has been rigorously eschewed for both practical and methodological reasons. Although there has been a widespread and generous solicitude for the peoples he studies, the anthropologist has attempted to avoid the kind of political partisanship that makes it necessary to embrace

totally the cause of any people, no matter how oppressed, in disregard of the welfare of the larger society.

While a mere recitation of these standards of behavior can be presented in a favorable light when compared with the procedures of many of the other human sciences—which, while deprecating the need for human experimentation have also treated human subjects like guinea pigs—there is a growing confusion in the minds of leaders of emerging nations and in the minds of young anthropologists themselves between the ethics of the past and the ethics required in a world in which the search for self-identification competes with accusations of racism against all other groups with self-identifications. Standards of absolute and uncompromising moralities in human relations call for an uncompromising espousal, for example, of the cause of black South Africans, even though it might lead to the massacre of white South Africans, and to the assumption that work done under colonial auspices in the past was necessarily contaminated and exploitive of the peoples under colonial rule who were studied by anthropologists. Records of earlier and more primitive phases of cultures now reaching nationhood, which the anthropologist made as an obligation to the people themselves and to his science, are often found incompatible with the current versions of a new nation's past. As the insistence on the ethical position that all racial differences should be ignored has been succeeded by an insistence that racial differences should be reified, emphasized and given specific recognition, work done within the older anthropological conventions become suspect. Other complications in the last 30 years (Nazism, Soviet dogma about sequences of human evolution, opposition to Lysenkoism, the Civil Rights movement in the United States, anthropological interpretations of poverty) have all conspired to confuse the understanding of the anthropologist's role by others and by himself. Responsible objectivity and commitment to the longest time perspective and the largest whole that he can envisage, responsibility for all "foreseeable effects," are difficult to maintain within this rapidly changing world scene. Certainly, in any planning for the participation of anthropologists in world policy planning, these changing ethics must be be taken into account.

Economics, Political Science, and Law

Chairman, Harold Lasswell

Cochairmen, Oscar Schachter, Jan Tinbergen

LASSWELL: The first of our discussants is of the discipline that the rest of the social scientists examine with mixed feelings of respect and envy, namely, economics. Prof. Jan Tinbergen.

TINBERGEN: I propose not only to give a very brief summary of my paper but to add a few remarks that are inspired by the discussions in these two and a half days. In my paper I trace how, during the last century and a half, both the aims and the means of social economic policies have changed. A number of social objectives have been added to the aims, especially care for the weak and income distribution generally, but other social objectives as well.

Around 1850 it was believed that nonintervention in the free-enterprise system was the best policy, so that there were hardly any economic policies other than those needed for so-called internal and external security. Today many problems are still solved in that way, but an increasing number of deliberate government activities and tasks are now deemed necessary, such as social security schemes, taxes on high income and wealth, regulation of total demand, regulation of unstable markets, such as in agriculture; practically the whole field of education is now being paid for by the government, a considerable portion of transportation and energy is being produced in most countries by public authorities, et cetera.

Perhaps it would be interesting to remind ourselves that pollution is not as new as it seems to be. Around 1900, laws were enacted in a number of countries to prevent certain kinds of difficulties that enterprises could cause to the environment and to make their establishment dependent on government permit. But, of course, the dimensions of the problem have grown enormously.

I should add to this list the government activities that we now recognize as necessary in most countries and on which, unfortunately, large amounts of money, as well as human lives, are being spent for ideological controversy, which is probably overestimated on both sides; I am, of course, referring to the question of war and what seems to be the basis for the present-day wars that are most in our minds.

In my opinion, war has been a threat to human welfare for a long time, but of course nuclear weapons have changed war, made it into really total war, to use that phrase of Hitler's. The tragedy is that there exists a common interest in banning war, but neither the West nor the East has found a legal shape that can be given to that common interest. The solution to the problem has not been indicated so far, unfortunately, by any of the contesting activists unless they simply want to take over Russian society. I do not think this is a very imaginative solution, so we still have to find how to give shape to that common interest.

I would like to add a few remarks on how we might deal with some of the dangers that have been pointed to so eloquently by several of our colleagues from the natural and social sciences.

The exhaustion of some of our natural resources is threatening, and pollution of air and water have already been mentioned. But, in my mind, the most important problem in the socioeconomic sphere today is the question of the developing nations. Another example is the requests for more public means, that is, more manpower, more capital, et cetera, on behalf of further research to be done.

What sort of remedies would economists generally think of? I think economists have in the last 10 or 20 years been accustomed to trying to absorb some of the lessons that the other social sciencies were able to teach them. I think that many of the concepts we are using, such as welfare, have been considerably broadened and that some of the framework used by economic planners—or those who prepare economic policy, to put it in simpler terms—can be well used to integrate some of the problems under discussion. Of course, the contributions would have to come from many other people, but the framework, I think, is there. Let me cite by way of example a few of the remedies for the evils that have been discussed in the last few days. First of all, some of these problems can be solved in an automatic way by changing prices. For instance, if certain resources become more scarce and the prices automatically go up, we then restrict our demands and shift them to less-scarce goods; it may be that if food becomes very scarce we will save on that, which in some countries is still possible. If paper becomes scarce, there would be a great possibility of saving: the number of pages in the New York Times could be reduced to one-tenth, especially by leaving out the ads, or at least reducing their extent.

Certain minerals may become more expensive because of scarcity, and we will have to switch, perhaps, to the newer artificial products. Some commodities that have in the past been free, such as pure air and pure water, in the future will have a price, and we will have to pay for them through our taxes, or perhaps include the price for air and water as a sales tax on the price of another commodity. Of course, we will need better means of calculating prices. We do not always account for the costs of the effects of some industrial processes. If a certain production process causes pollution, then the enterprise causing that pollution should be charged for it; automatically this will increase the price of the commodity being produced.

Some, but not all, of the problems can be solved that way. I see ahead a number of new tasks for public authorities—for example, supervision of industries as they already exist, which would be necessary on a much larger scale in order to avoid pollution; or, to take another example, supervision of commercial fisheries to prevent overfishing.

Also, public tasks will arise in the field of international health and strategy. It is absolutely certain that there will be many tasks in that field; there are many studies—for example, the Report of the United Nations Development Planning Committee, which suggests an accelerated development policy that would certainly require that a number of the rich countries simply make more of an effort on behalf of the developing countries. It is not a question of favor; it is a question of cooperation and taking care of the common interests that we all have in such development.

Then, as a final example of newer government tasks, I should imagine that certain forms of waste would be handled through government measures.

To take one of my own interests, I think that certain buildings could be less luxurious; this sort of thing could be subject to government regulations.

But the important question that arises is: on what level of authority should these decisions be taken? Some can be made at the local level and others at the national level, but there remain a number that can be taken effectively only at the international, and perhaps even at some sort of world, level. I say "some sort of," because I don't know whether the East is willing to integrate with us. I, for one, hope so, but even if the Eastern representatives at the United Nations were willing there is still another, China, which is not a member, and there is a question as to whether it would want to cooperate. I imagine we would have to start in a small group, or maybe the groups that are now indicated as West and South—that is, the Western, developed countries plus the developing countries, to the extent they are willing. On what does this depend? It depends on the level you choose. I think it is essentially not a question of political choice but of technique. It depends on the nature of the effect of the measures or of the effect of the evils that we want to eliminate. For instance, take water pollution. It is almost sure that we cannot solve this problem at the national level; we must do it, perhaps, at the continental level. The recent case we set out to solve in my own country, the pollution of the Rhine's water, was clearly a case where not national authorities, but only international authorities, could make appropriate regulations to make it possible in the future to avoid such problems.

Also, if we think of such problems as radiation, it might well be a world problem for which a world authority would have to be created.

I think it is interesting that our colleagues in the East also now understand that the preparation of policies, or planning, as we usually call it, has to be done on various levels. We are debating what quantitative indicators can be found in order to determine the appropriate level. So I do think that we need international agencies, but the big question is, of course, how do we get there? And I see only, unfortunately, the not-so-very-convincing example of how we tried in Western Europe. The only possibility I see of creating an international agency is for the present so-called autonomous or independent governments to agree in a treaty that such an international agency be established and that it have certain tasks; this is the big struggle, I am afraid, that we must join; it will not be very easy to win, but it should be done; it must be done.

It follows from what I have said that the means available to any public authority will have to be redistributed, that is, to be distributed differently from the way they are done now, because no priorities have emerged for new taxes and we must, perhaps, reduce old taxes. In short, by careful calculations we have to find out what the priorities are. But, on the other hand, we may hope that perhaps some new inventions will come to our rescue in some cases where we can not yet see a solution.

A last word about ethics, which has been mentioned several times. For us, for the economists, ethics is identical to what we call welfare, and the question is to define what we believe is welfare, what the components are, what the relative weights are; this is what we want to maximize whenever we design socioeconomic policy. There are no restrictions as to what elements can be included, so in that respect we can, indeed, see the framework into which everything is integrated, all desires that are brought up by other quarters, provided that we are willing to try to determine the weights. And, of course, there are differences among people. They have to be considered in deciding how the weights are

to be chosen. We have asked a question: Don't we also determine, partly by what we decide at present, the welfare of future generations? This is, of course, perfectly true, and the arguments that are brought up are absolutely convincing. This is certainly not a new problem to economists, even though it has been tackled only in the rather restricted way in which economists usually start their work.

SCHACHTER: The subject suggested for me to speak on was the organized planet, which I suppose does refer to the numerous international bodies that now concern themselves with the environment. Dr. Tinbergen has just raised the question, perhaps a little too much in terms of the new machinery, since, in fact, we have a rather complex structure of multinational organizations on both functional and regional bases that deal with many of the problems that are of concern.

The central focus of attention at this time is the Stockholm Conference to be held in 1972. That conference, which is more or less a standard response of the United Nations to problems of this kind—that is, the conference method, has become a great magnet for drawing together, attracting a number of ideas, proposals, studies, facts. It seems to me that, in the context of that conference and the conference itself, in the years of preparation—and, one hopes, the years following, a great deal of progress will be made toward determining exactly where we want to go. My own view is that many of us become beguiled by the notion of a global authority, a brand-new international body that will do all the things that are necessary to solve environmental problems.

I think this is unlikely. I think, on the whole, it probably would be counterproductive to put a major effort simply into the creation of an organization, a new organization that will have many purposes, that will have many different functions, and that will attempt to cover the whole field. On the other hand, I believe that what we do need in this field is a much greater development of a variety of international institutions, either on the basis of the present assortment of organizations in some cases, or, where necessary, the creation of new agencies. I think that in order to get the kind of participation, the kind of expertise, the kind of energy and resources that are needed to move into this field, one has to look to a lower level of authority, to use Professor Tinbergen's terms.

We need a great deal of decentralized activity, the kind of institutional activity that will attract the governments, the nongovernmental bodies, and the individuals who have most to contribute and who would be most likely to join in an effort in which their participation would be direct.

So, I would like to see a great pluralistic development in this field. I would like to see more organizations that have an ecological-regional focus, such as might be established for the Arctic region or for the Amazon or for other identifiable regional areas. I would like to see development of a great many functional-type organizations whose work perhaps is not now covered by existing agencies; the oceans themselves have interlocking organizational interests, but there are organizations that need to be filled.

I think there must be an attempt to bring this onto a more professional, or even personal, level. We need to think of ways in which scientific and professional organizations will be able to take their parts in the international constitutional scheme that is developing in this area. The kinds of functions that would be performed have been fairly well pointed out in connection with the preparations for the Stockholm Conference.

Again, in almost a typical way of international organizations, on the agenda is a grand declaration that will presumably set forth principles or, if you like, objectives that would be pursued. Alongside of that there are proposals for expansion of informational and fact-finding activities. In the current jargon, these are almost always described as monitoring activities of a particular kind, and a good deal of consideration is given not only to monitoring in the simple sense of fact finding but to the development of new techniques with built-in monitoring on industrialization projects, on development projects, on a great many of the positive activities that Dr. Tinbergen referred to.

There is also some emphasis on what might be called the political aspects of this. If the Stockholm Conference serves no other function, it will constitute, one might say, a big bang; it will create the kind of noise that it is hoped will move those governments that, up to now, have shown only a slight disposition to be concerned. But I don't think we should overstate the public-relations side or the propaganda side of this. I suppose there is a serious question whether the publicity and propaganda and the near hysteria that seem to be affecting people who discuss this subject might not have, in the end, adverse consequences. That has been pointed out by many, and I need not dwell on it.

Second, the problem is certainly beyond a problem of the mere will to take steps—that is, the obstacles are not merely those of a lack of will power. There are, as Professor Tinbergen noted, a number of serious problems, cost-benefit problems, one might say, calculations about whether it is better to put the sacrifice in one place rather than another.

One of the major difficulties faced in the discussion of this is the lack of knowledge about the links that arise; certainly people do not know about the difficulties that are now being revealed in regard to the many water resource problems, the Indus River problem, the Aswan Dam, the Rio Grande development—all of which carry with them a great many serious consequences, which may be irreversible. So that I think part of the work of the international community should be to get beyond the present level of naïveté and make it clear that this is simply a matter that requires everybody to pull up their socks and get going.

In fact, there is an enormous amount of technical and scientific work required and a much more serious set of political questions than seem to be realized. And I say my answer is, so far as the levels of authority for answering this, that there must be multiple levels of authority, they must surely take account of Professor Tinbergen's point that the actual effects and consequences of the objective factors must be considered, but I would add that they must also take account of the psychological, nationalistic, and political elements that are going to enter the picture. We will not, I think, be able to blot this out with a set of blueprints; it is going to require a good deal of negotiation and a good deal of political activity before we can move into a higher level of organization, such as Professor Tinbergen would like to see. I think we would all like to see that.

MCDOUGAL: I would like to address myself to some of the remarks that have been made by earlier speakers. I was extremely impressed by the earlier discussions by our physical scientists, perhaps because I do not know anything about the subject and do not know what they are leaving out.

When I heard the physical scientists talking this morning, I could not help reflecting why I did not have any great discoveries in my paper about the interrelations of law and society or about new techniques for studying law.

As I began to reflect on why I had not turned up with great recent discoveries, my mind went back to the early 30s in this country, at which time we had a tremendous spate of effort at empirical inquiry about law. Most of these efforts came to practically nothing because the people who were undertaking them did not have adequate funds. Lawyers get success much too quickly for more active occupations, and about all I could think of was some work that was going on recently concerning juries, which is relatively inconsequential in the larger picture, or some of the studies that Professor Lasswell has made about factors that affect decisions, or some of the material that Professor Dror presents in his memorandum.

But I began to reflect that maybe there were more profound reasons why I did not have this kind of material. I think it is because of our contemporary conception that law is not something autonomous; you have an inherited body of rules that inhibits behavior, but it is a process by which the members of the community clarify and implement their common interests. All law is policy, though not all policy is law. I thought briefly on the function of the lawyer—and of the legal scholar who tries to assist in this function—which is to take the knowledge that you people produce and try to employ it in this process by which common interests are clarified and implemented.

We need precisely the same techniques for policy clarification that you need. We need the same skills, the same techniques for historical study, for study of past decisions, to draw on past experience, that the sophisticated historian employs or the cultural anthropologist has developed in recent years. We need the same understanding of conditions, the same scientific skills that all of you who work with the human personality require, that all of you who work with the factors that affect social change require. We need the same skills, the same techniques for projection into the future, and when we come to the creation of new alternatives in principles and institutions, such as Professor Tinbergen and Dr. Schachter were talking about, there is a tremendous equivalence of institutions and principles that might serve the same policy goals, the same value consequences; any lawyer who thinks that there is only one way to do something immediately convicts himself in the eyes of the profession of being an ignoramous. What is required is the fitting of new legal techniques to very specific contexts. This brings me to my lack of appreciation of what happened this morning, my very great sense of unease.

The way the problem was left, in fact, the way our problems have been left through most of this conference is—well, let me recall Mr. Maddux's invitation to the social scientists to come to Washington and be wined and dined and be given great grants by the World Bank to go out and solve a lot of their problems. He began with one problem with which this conference is concerned, but which relates, perhaps not most directly, to the environment, though I will proceed to relate it. Mr. Maddux wanted to know what aggression is, what you people know about aggression, and he talked as if he knew what the word "aggression" referred to. I would like to suggest that before he employs social scientists, he needs to employ a good lawyer to delimit his problem for him. This happens to be an area in which I have specialized. There is a complementary concept to this concept of aggression that he was throwing around so loosely, and that is the concept of self-defense. If you relate these two high-level abstractions to empirical reality, you will see that they refer to a whole process of interaction between territorial communities.

The policy that Mr. Maddux was calling attention to was that embodied in Article 24 of the United Nations Charter, and since I used it in my paper, I have it here, and I quote: "All members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state or in any other manner inconsistent with the purpose of the United Nations." If I had Article 51 with me, I would bring forward this concept of self-defense, of self-help; every civilized community has both these concepts. It is indispensable to law in any community that unauthorized coercion, violence, force, be restrained to the utmost. What we mean by law, in one simple sense, is a decision taken in accordance with community expectations, not arbitrary, episodic changes that go on. On the other hand, not even our most mature societies have been able to dispense with the concept of self-defense.

Suppose you have an interaction across national boundary lines, what Professor Jessup has called a transnational event. Let us take one that specifically relates to environmental problems: Suppose some state acquires the technological control over weather resources in such a way that, by manipulating the air currents, the atmosphere, the clouds, the water above its land masses, it can impose severe destructive effects on a neighboring state; it can make its fertile bottoms become deserts, its fields dry up, its people go hungry and thirsty.

Mr. Maddux wants to know what aggression is. The lawyer who has to advise, the lawyer who has to decide this has to be able to decide whether state aid is imposing deprivations on its neighbors. He has to decide whether this is unlawful or is lawful, is self-help or is self-defense.

Let me indicate to you what is required. If you just make minimal sense out of this question, you have to know who is acting with respect to whom, what are the territorial communities, how big are they, what is their relative strength, what are their demands in relation to each other? Is this being done for purposes of conservation, of trying to save something in the original state, to get rid of a desert or make a valley bloom, or is it being done for deliberate destruction? Is it being done as part of a concerted scheme to extend rule over a large area?

There are a great many factors relating to the demands of the parties, their expectations, their identification, who they think they are, and for whom they are acting. There are other features of the context that you will want to know: Who else is affected in this, and to what degree? What is the geographical area affected? What are the time dimensions? You have to go into these questions in great detail. What are the relative bases of power to the parties? What are their relative resources, their control over people, their institutional efficiency? What instruments of destruction accompany their manipulation of the weather? Has there been a great fanfare of the diplomatic instruments, the ideological instruments? What is the verbal accompaniment? Is the military instrument being readied? Are there troops at the boundary? Do they threaten to move or close off other resources? What, in detail, is the degree of destruction achieved or threatened? Are there realistic expectations one party will have to resort to the military instrument for its self-defense?

Now, this is just the beginning of this kind of inquiry. Before you can go much further, you need to clarify in minute detail the policies that are embodied in this policy, which I said was of minimum order in any civilized community. When you say "minimize coercion," that is, lessen it, it is a very

ambiguous concept. Does it include the long-term prevention of the conditions that lead to this kind of destruction? Does it include the immediate deterrent of destruction that is threatened in the here and now? Does it include the restoration of order, the stopping of destruction once it breaks out? Does it include the rehabilitation of the parties, the short-term binding up of wounds, the long-term reconstruction, the effort to create the conditions so that the conflict will not happen again? The specific measures that the general community may invoke in the kind of context I have described will vary with every one of these subobjectives. So what I am trying to say to Mr. Maddux is that, before he can invoke the use of social scientists, he needs to have his questions sharpened, in quite minute detail, relating to the entire context of a whole string of objectives, objectives I have only begun to indicate.

I related this problem to the environment; this is one of the problems that we face when we talk about securing a global environment. I would like to generalize what I have said to everything that we have been talking about. In the opening pages of my paper, I tried, in a few very broad strokes, to formulate our problem in terms comparable to those I have just been using about aggression and self-defense. This kind of formualtion is what I have missed most in this conference so far. As lawyers trying to delimit the problem so that goals can be clarified, so that we can draw on past experience and suggest alternatives to secure the common interests, we need to be able to clarify these environmental problems, population problems, genetic problems, in much greater detail than we have yet done. The first thing we need to know about the environment is what the detailed damages, the injuries to the environment are. To what degree are these injuries an indispensable component of the processes of production?

To what degree are they not?

What are the alternative ways of producing the differential potentialities for damage and injury that are involved? What are the factors that affect all the injuries that we can describe? What are some of our basic goals about prevention, deterrents, rehabilitation, reconstruction, et cetera, in minute detail? What are the technical solutions that the engineers, the community planners, the people who are geared for those problems would recommend for the solution of these problems?

It is obvious that the solutions are all interdependent.

We know enough to know that the basic factors underlying all this environmental injury are the violation of the interdependencies of man's practices in the enjoyment of his resources, the nature of the resources, man's nature itself. We need to examine these interdependencies in much more detail than we have. As one who began his life as a community planner, I do not believe that the technical solutions are beyond us, that the imagination of man is not enough to cope with this. But before we can bring our recommendations to bear in anything like rationality, we need to have the problems formulated much better than they have been. Here is where we need the knowledge and skill of all you social scientists. The question posed here to the legal specialists was: What are the potentialities of our authoritative processes of decision for clarification and implementing common interest for dealing with these problems?

I would like to introduce a slightly different note from that which was introduced earlier in some of our other discussions. I have colleagues who run around the country declaiming that we are in a quick race for survival, that in five years or ten years if we don't do this or that or the other, we will all be swimming in oceans of poisons, and that the law is all against us, the law is outmoded, that we have to scrap it all and begin anew. I don't happen to feel that way at all. I think we have tremendous legal assets for coping with this problem and for making use of the knowledge and skills you people possess. I have organized the legal bases under three different headings. The first relates to our general understanding of law, of legal processes, our skill in manipulating these processes of authoritative decisions or theories, and other procedures.

The second relates to our inherited world or global constitutive process. The thesis is that we have, on a global scale, a basic constitutional law process or structure that is functioning reasonably well.

Third, our final asset is the inherited public order, our inherited prescriptions, policies, practices about environmental problems.

In terms of our theory about and conception of law, we have moved, after many centuries, toward a sociological conception that will make use of all the findings and procedures of modern science. When we reject the message of natural law approaches that have dominated the thinking of mankind for some five or more centuries, when we reject the fatalism of the historic approaches, there are today very few adherents to the European or English notions of historical jurisprudence.

We reject the alleged autonomy of the analytical or positivistic approach that regards law as something unique and different; I am now talking of the working assumptions of practicing lawyers; I am not talking of the debates you get in the academies. We still have philosophical debates in the academies about the relative merits of all these different approaches, but they are relatively inconsequential. The operating lawyer today works with intensely sociological presuppositions that permit him to make use of all of *your* knowledge and skills. If I had time I would spell this out in terms of the observational standpoint, the focus of attention, the different intellectual tasks that are regarded as relevant, the need for commitment, for explicit postulations of values.

Let me say only a few words about the focus of attention and relevant intellectual skills. In terms of the focus of attention, it is squarely on decision, not simply rules, but rules and operations of what the choices are that are sustained by effective power, by severe deprivations or high indulgences, not simply decisions, but authoritative decisions, decisions that are taken from the perspective of authority. The perspective of authority we work with has been cited several times in this conference. The perceptions are as old as the pre-Socratic briefs, and the expectations are those of the members of the community about the decision process of the community, what they want decided by their community, how they want it structured. It is not something esoteric or mysterious to be derived from the laws of nature. It is not simply authoritative decision, but processes of decision. We are interested in the whole continuous flow of sustained choices.

In this process of decision we make a distinction between two different kinds of decisions, the constituted decisions and the public-order decisions. The former decisions, those that establish this process, say who the authoritative decision makers are, what the basic policies are, what the established structures of authority will be, what the authorized procedures and the different kinds of decisions are that must be made.

By public-order decisions we mean the whole flow of decisions that come

out of this constitutive process to regulate other values, the wealth process, human rights and civil liberties, education, enlightenment, the whole spectrum of value processes. Beyond a process of decision, the contrary decision demands explicit relation to social process. Every community has a comprehensive social process exhibiting interdependencies, interdetermination like our noble community. Apart from this is an effective procedure process. This constitutive process is maintained and operated by the people who hold effective power in the community. Authoritative decisions are a response to events in this process and in turn have consequences for this process. All of this has to be taken into account. Beyond social process the contemporary theory talks in terms of community process. We all live in a hierarchy of communities from the local to the global. Since the problems are global, the response has to be global in terms of hierarchy of communities.

If I turn from my contemporary theory, which I think is entirely adequate, to this inherited constitutive process, in much of the literature I see it begins with complaints that these problems are global but the process of decision is not global. I submit to you that if you look, as an anthropologist would look, the process of decision *is* global. It is becoming tremendously democratized. In recent years we have not only the nation-states but the international governmental organizations, political parties, pressure groups, private associations without number, and the individual human being playing a role. If we look at the policy by which this process is maintained, we have had a clarification on this basic policy of minimum order that I mentioned earlier. Article 24 of the U. N. Charter was a tremendous advance toward the notion of repressing unauthorized coercion. The Declaration of Human Rights covers a dozen other declarations, and we can use a movement toward the clarification of basic demands.

We have had a tremendous proliferation of new structures of authority with international organization. We have had tremendous new power conferred upon this central structure of authority. The terms that Professor Tinbergen used, this dichotomy between international concern and domestic jurisdiction, has almost disappeared. The world is in it in terms he suggested, in terms of the relative impact of activities; everything today is global in its impact. There is increasing inclusive control over the bases of effective power. There is tremendous improvement in intelligence function, and by this we mean a good deal more than the monitoring that Dr. Schachter was talking about. The procedures for application are tremendously improved with a movement toward compulsory application in the bank procedures, in the new draft convention on treaties.

Shifting now to the public-order inheritance, I deal first with the allocation of resources, the important point being that most of the important resources of the world other than the land masses have always been allocated under inclusive controls: the general community makes and prescribes law for the oceans, the air space over the oceans, outer space, the international rivers. There is a tremendous range of resources already in inclusive control.

The exclusive appropriation is honored only by genuine occupation and productive use, but to turn to the prevention of injurious relations of cross-boundaries, we have not only these major depreviations that we have talked about, but we have a pretty good law of torts when one state wants to use its resources to the injury of another. I could run through a tremendous number of these inherited prescriptions that facilitate a rational enjoyment of the

environment, but I think I will conclude and say that when it comes to the recommendation of alternatives for improvement, I would follow the lines that Dr. Schachter and Professor Tinbergen followed, but I would suggest a much more comprehensive approach, to look systematically at the whole global constitutive process and make an effort to improve every feature of it. This relates not only to the environmental genetic problems but to other things as well, to mobilize pressure groups and political parties; perhaps we will have an opportunity to talk in terms of these alternatives later.

JESSUP: Unhappily, I have not been able to attend previous sessions, and therefore I am not in a position, as Professor McDougal was, to comment on remarks made at earlier sessions, and I must confine myself, therefore, to what has been said this afternoon. Since exaggeration can be the soul of brevity, I shall exaggerate one institutional element that, it seems to me, has been passed over by all speakers. I refer to the element of adjudication.

Mr. McDougal—and I think I quote him exactly—said the lawyer has to decide. As a person who has been a judge, I say the lawyer does not have to decide, he merely has to try to persuade the judge how the judge should decide. Unfortunately, in the context in which Mr. McDougal was talking, which was the context of the problem of the distinction between aggression and self-defense, it is left in our present international system to the lawyer to decide in the zones of making a recommendation to those people whom Professor McDougal calls the decision makers, and these are the politicians, these are the government people; they are not the judges; they are the people swayed by self-interest, and, unhappily, the lawyer frequently tells them what may be the course that they can follow without getting into too much trouble, regardless of the social consequences for them or their neighbors or for the total environment.

In the previous comment, if I may start first with what Dr. Schacter said, about the 1972 conference in Stockholm, he spoke of the way in which these conferences usually begin. You have a noble declaration, and you have what he called the monitoring procedures, and then you have the political promotional procedures, and this is all very well. Then you must pass, I suppose, if you want to get results, to what Dr. Tinbergen spoke of—treaties. You have to get an agreement among the states in which they will agree to be bound by certain rules or principles a little more specific than those general doctrines to which, in part, Professor McDougal was referring. But it does not end the problem when you have agreed on a treaty. Every treaty, every agreement in the history of man, has had to be interpreted, and you must have some authoritative body to make the interpretations. In every modern society the interpretative body is some kind of court or tribunal.

In terms of problems with the environment, et cetera, let me indicate—and there has been some passing reference to this by Mr. McDougal of the situations that point up the role of and the necessity for the role of the courts—you have the recent declarations of Canada insisting that it must take such measures as it sees fit to preserve its Arctic territories from threatened pollution. The United States has questioned whether Canada is not stretching its powers too far, and proposed to the Canadian government that the question be submitted to the International Court of Justice at The Hague, and Canada refused.

In an earlier case, some years ago, a smelter on the Canadian side of the border was pouring sulfurous fumes across the Canadian frontier into the United States, with resulting damage to forests and to human beings. In that

case, Canada and the United States agreed to submit to an international tribunal the question of liability, the question of damage, the question of mutual control. That particular bit of pollution of the atmosphere was taken care of, eventually, through the authoritative decision of a tribunal that had to be set up by the agreement of both parties.

Dr. Tinbergen referred to the problem of overfishing. This has been regulated over and over again by treaties, sometimes with considerable success, as in the North Sea, in the North Atlantic, and to a certain extent in the North Pacific. The amount of success under the various agreements varies; perhaps the most successful agreement, which also followed an international adjudication, was the arrangement that is now participated in by the Soviet Union, Japan, Canada, and the United States for the protection of the fur seals in the North Pacific and the Bering Sea; a procedure has been worked out for the conservation of that particular resource.

I have taken the liberty in my paper to quote from one of our colleagues. Perhaps I have misapplied it, but I have referred to this expression: "The fossil ape encrusted in our hearts." I would suggest that in this process of international adjudication, the question of what is in the hearts or minds, what are the motivations of the governments concerned, is of the utmost importance. Dr. Tinbergen may recall the little dispute of his country with neighboring Belgium over a small parcel of frontier land. It was a very curious situation: the boundary was uncertain; it ran right through the middle of the billiard table in the town, and one could gamble on one side and not gamble on the other, because the laws of the two countries were different on that form of amusement. The question was submitted to the International Court of Justice, and the court decided it. The lawyers were very gay. It was a cheerful split, and it was settled happily. And recently there have been reports on how successfully the details have been worked out.

There was similar good will in one of the most recent cases before the International Court of Justice, a fight between the Federal Republic of Germany, Denmark, and The Netherlands, with regard to the areas of the sea beds or the continental shelf in the North Sea pertaining to each of the three states, so that each one would know what part of the areas could be exploited by each state. Although the judgment of the court has been criticized, that is what lawyers are for, and that is to criticize the decision of courts, particularly if the lawyers represent the losing party. The recommendations of the court in that case, although not final, have led to what I understand is a reasonably satisfactory arrangement among the three governments, which have followed the procedures indicated by the court.

On the other hand, there are cases that have come before the International Court of Justice in which there has been the most strenuous underlying conflict, disagreement, violence of feelings, which have certainly been characteristic of the episodes in question and may have been reflected in the outcome of the case in at least one situation. I refer particularly to the dispute between Ethiopia and Liberia on the one hand, and South Africa on the other, in reference to the disposition of what was the mandated territory of Southwest Africa. There are other situations of that kind. I don't think it is necessary to have an elaborate vocabulary or elaborate theory or elaborate philosophy simply to say that if there is a situation that at least a certain number of governments are willing to have settled peacefully and definitively, this can very well be done with the existing machinery.

It would be very helpful to have certain basic agreements concluded, for example, at the Stockholm conference in 1972, but until we have something a little more than what Mr. McDougal talks about in the matter of legal skills, until we have a little more than the kind of organizational arrangement that Dr. Schachter spoke of, until we have a little more of what Dr. Tinbergen was referring to as the economic pressures forcing governments to find a solution to the dangers of environmental pollution and similar other difficulties, until we have more of this kind of pressure resulting in the change in governmental attitudes, the final utilization of this last resort for international adjudication will not be with us.

DROR: I think it is impossible not to sense a certain dichotomy between the contribution of the physical sciences and some of the social sciences on one hand and the contributions of this afternoon. I think this is not an accident but will reflect quite significant differences of approach.

Let me start with the apparent movement of physical sciences and parts of social sciences, not including economics, which is a chapter by itself, into prescriptive recommendations. In the discussion of birth control, in the discussion of pollution, in the discussion of conflict resolution, and in many other of the fashionable discussions, we have a jump by many hard scientists—to use an incorrect but widespread slogan—into prescriptive recommendations, and I can but share the feeling expressed by Professor McDougal that most of these recommendations are presented in a way that we would not expect a good lawyer to adopt, but in the way of a bad lawyer, who has never heard a Brandeis brief or any other devices for bringing knowledge and recommendations together.

To be only slightly overextreme, I find in many of the prescriptions offered by physical scientists, life scientists, sociologists, and some others, for the ills of society, an undistinguished mix reminding me of a ruined salad, between value assumptions, risk, time priorities, agreed facts, doubtful facts, and many other components, all of which are presented in an unclear mix, usually unclear to the person making the recommendations, and usually presented behind the umbrella of "I am an embryologist; therefore take my opinion on pollution seriously; take my opinion on birth control seriously." This is very difficult to accept. I think that one of the missing links, or one of the missing underlying necessary elements, is, to use somewhat overphraseological language, a prescriptive silence, or an elaborated methodology, or at least a worked-out analytical framework for presenting recommendations. And, indeed, as Professor Tinbergen explained, the major advantage of economics is that the present part of such a framework—not a sufficient one, not a complete one, but the economizing idea of optimizing uses of resources—has been up to now one of the best frameworks that we have had for putting scientific knowledge together with values into explained and explicated recommendations and prescriptions we can understand.

The same is true for a very good lawyer's briefs, though somehow I am not so sure that they are as widespread as Professor McDougal represents. I agree this is what we want, but whether this is the norm of lawyers is quite another question, which we will defer until there is evidence brought forth by others. In other words, I think that we have here a clear need for a systematic approach to the question of how to improve decision making or policy making, or whatever you want to call it. The would involve not only the question of framework for analyzing problems, something

dealt with significantly in economics, but, even more important, the institutional aspects; what types of institutions do we need for better decision making? What types of persons do we need? What types of culture do we need?

Let us remember, for instance, that one of the problems in many countries —often called underdeveloped, but we will leave that term aside—is the question of "rationality content of culture." Without trying to define it, we can deal with it at least with conceptual tools. Now, this is beyond what we have. In fact, let me just take the illustration of pollution. Here I would suggest that, more important than the question of what good technological solutions we have to prevent pollution, is the question of what we can do in order, on a current level, to improve our handling of pollution issues. In other words, the main question should not be what to do about pollution in Los Angeles but how to increase the capacity of the Los Angeles decision-making community to decide pollution issues as they arise, as technology changes, as criteria change, and as aspiration levels change.

I jump here—and this is the only esoteric term I am going to use—from the decision level to the *meta*-decision level, or from the policy level to the meta-policy level. Meta-linguistics is a policy for discussing language; meta-policy is a policy on how to make policy. We need a step beyond available normal science, we need an additional approach, which was first proposed by Professors Lasswell and McDougal. Let me use, just for the sake of brevity, the term *policy sciences,* but don't mind the name. We would be better to call it policy studies, policy religions. To illustrate possible changes that may be necessary in the basic paradigms of knowledge, I will enumerate such new paradigms. One main concern with meta-policy was to go beyond the question of how to solve disputes; problem two, to present foreseen crises, and three, the question of how to improve our problem-solving capacity for the future. This is really a basic point.

Let me return to pollution. There has been very little discussion here today about how to change the politics of pollution and how to change the politics of pollution control. All the nice technical shortcuts have zero visibility and are, perhaps, very counterproductive.

Pure knowledge, after all, is often the most practical thing in the long run. The distinction between pure and applied research should not be mixed up with the distinction between pragmatic and highly basic knowledge. While one will agree with Professor Price on the need to encourage basic theoretic research, the question of what problems to direct our research at, what areas to select for pure abstract research, is quite a different one. To be brief, I think we can just as well opt for abstract-research issues that in the long run are relevant to human affairs.

The next illustration that I think is very important is the question of using the tacit knowledge of policy makers. Indeed, when we speak about waste of resources, one of the most amazing wastes of resources is that of, let us say, politics or policy practice. One learns a trade only through a very expensive apprenticeship. I do not mean the cost for the person himself, but for the side effects from his activities. Very little has been done to try to get people with experience to distill their experience, to pass it on to others. In other words, looking for research methodologists to distill the tacit knowledge of people with experience in policy issues, so we can try and build up some accumulations, is quite an innovation in research methodology.

The question of a time perspective, past, in the future: I was quite struck

by what I heard today and yesterday about how all or most of the contributions focused on our present problems: pollution control, birth control.

What about the problems that are around the corner? For instance, we have a promised invention, and soon we will have the chemical ability to influence the sex of the unborn child. Just think about the effects. This is one invention that will require government interference with intimate family decisions on a level that has not been practiced in any totalitarian society in history. Either we give up the balance of sex, which means a complete change of social structure, or we establish quotas. In some countries genetic ideas will be considered. In any case, we are sure to have much harder problems around, and one of the things we should do is to think in advance about them, rather than run behind popular-appeal problems, although they are also important.

In any case, think of the present as a bridge between the past and the future. Tying in future studies with historic understanding is a far cry from the approach of most physical scientists and, I am sorry to say, most social scientists. Lawyers are often, in this respect, much better.

The last point I am going to mention is explicit recognition of the importance of extrarational and perhaps irrational natural aspects of policy making. The question is, can we do something to increase creativity without understanding it? We can use black-box techniques. Some of the studies of research laboratories or, let us say, the question of the use of drugs to influence creativity for better policy making is certainly an important area for long-range study and research.

Let me say just a few words on possible implications. What we are dealing with is a question of a new symbiosis between power, on the one hand, and what is called the scientific approach, on the other. Instead of the pure scientific approach, I would prefer to say the uses of systematic knowledge, structured rationality, and organized creativity as contributions to policy making. Certainly this requires many more changes than I could easily achieve here.

As this is not a meeting of politicians, let me mention changes in the scientific community. The implications for scientists are very rigid. Easy implications entail new types of research organizations. Let us say "think tanks" as a main invention, to bring together science and policy making. Questions of new training and teaching programs as first proposed many years ago by Professors Lasswell and McDougal with respect to policy teaching at law schools are only now being tried in some respects in the United States. We know that we in the university are very conservative. More important than such marginal changes are the questions of our own self-restraint and humility and recognition of self-limits: one cannot be an embryologist or a political scientist and get up and say, "I support measure A, B, or C for birth control, therefore the government should do it," and sit down. The limitations of recommendations, the limited knowledge in one or two disciplines, have to be recognized from the moral point of view; although we might try to influence citizens as a professional élite, the legitimate judgment belongs to the politicians we regard as legitimate, and efforts to usurp it and smuggle in the decision and say that the Catholic Church in Country A should do so and so, and the government in Country B should do so and so—on what moral basis do we presume to tell them what to do?

We can say, as citizens of the world, unless you do so and so, I think the

world will be ruined. And if you believe in a religion, you prefer the world to be ruined rather than change your mind—at least the moral dimensions are recognized, and the technical and professional implications. Being an expert in embryology does not make one into a platonic type of universal policy solver. It is a much harder job than that, and we are starting only now to solve the problems. But in many respects we have to know how to look for methods, how to treat the more complex problems.

CATLIN: First, I would like to congratulate Professor Dror on the extreme clarity of what he has to say. It serves as clarification of much of our discussions.

The subject of environment is not a new one. It goes back to Aristotle, who wrote on the air and the water. I think that perhaps we, especially, tend to such speculation today because of the reaction of the astronauts; they started their way back to the blue and beautiful world, and we had, to some extent, reversed seeing it. Instead of discovering other worlds—and we are merely a small part of them—we are becoming again earth-centered and concerned with saving this earth. All of us, I presume, will be sympathetic with this. I have a feeling that when President Nixon and Mr. Harold Wilson are in agreement, the next theme of the 70s will be environment.

It is a method of distracting attention from the problems of poverty and war and race, which are highly controversial and somewhat inconvenient to put in the foreground. There is a risk that we are being offered a placebo. There is a risk we may go in for boondoggling, that the humble people who used to be called geographers will descend from those attic levels and come down on the ground floor as ecologists, doubling their income and becoming the prophets of the 70s. Against that, I am frank to say I want to issue a cautionary warning.

I do not want to speak today except with brevity. However, I would look back to the Rome conference, four years ago. You remember in those days the World Academy had three working projects: One was desalinization—of obvious value—leading to, perhaps, fertilization of the Sahara. It is not my purpose to discuss that. I merely throw it out as a positive suggestion.

Another project was the World University, which I will not discuss here except in passing, and the third problem was that of conflict, of peace and war. That I do want to comment on. I repeat that we, all of us, are against matricide, and we, all of us, are in favor of the good earth. When we tackle these environmental aims that are so popular and so applauded, the only thing that emerges is the issue of planning. As soon as we start this planning, we will come up against controversy. Many people will find the pace of this planning inappropriate. I prophesy that within five years the pollution program will be steeped in bitter controversy—spokesmen for industry, air, automobiles, chemicals, et cetera, will say, "Why are you trying to settle these things for us? This is contrary to free enterprise."

In our meetings I have heard several people say that the final objective is the increase of free will. I doubt it. On the contrary, I think that our planning tends quite rationally to decrease the area of freedom. If we choose the phrase "increase of rational free will," I would subscribe, because the test word will be "rational."

In discussions around the biological sciences here it has been said that we are going to have to make decisions that will affect future generations, whether they like it or not. They will not be left with a free will. Our decision is to

risk ourselves on how we are going to shape the future. Sometimes free choice is merely another name for egotism.

There is a basic conflict between technocracy and human values. If capital-punishment judgment were submitted to most people, I suspect most people would be in favor of capital punishment. One of our speakers yesterday suggested that the machine was obviously going to open powers for man and that technocracy will do the same. He has forgotten that machine and technocratic developments have their own momentum; the automobile lays down certain rules that must be followed if we are going to get efficient transportation; it does not depend on what you look to as a pretty paradise, it depends on the mechanical or technological aspects of the automobile. The computer is obviously advantageous, and most human beings should be like lead slugs that will be fitted conveniently into a slot without too much originality and without causing too much disturbance. I think that we ought to ponder this basic trouble.

One of our greatest leaders of youth, Henry Marcuse, age 71, seems to have got into a muddle, not being sure whether he is praising technocracy or damaging the system that, in large part, is shaped by technocratic convention. The particular themes today are economics, political science, and law. We have had a very able and outstanding exposition on the matter of law. To revert to the matter of purchases, a Marxist would say they revert to the matter of economics, but after all, the Soviet Union is the outstanding example of policy determining economics rather than economics determining policy.

I recall, considering political science, a statement by the late Lord Attlee about scientists. When I repeated it to Robert Oppenheimer, he was not pleased. Lord Attlee said: "I have always found that the physical scientist's judgment in political affairs is much worse than that of the ordinary man in the street." This sounds like a paradox, but I don't think it is. I think, like Professor Dror, that if a man is an embryologist and says, "I am a super-expert in embryology, and now I am going to tell you something in a field remote from embryology," we should have a certain humility, but, on the other hand, there are people like Keynes; there are people who are relevant and tremendously effective in the currents of political affairs. If we get a Keynes or a political scientist in the same position, that is magnificent, although Keynes was not devoid of vanity. I think that the crux in this field of short-range and long-range decisions is to have democratic confidence in the people's making short-range decisions within their own experience; but I also agree that the experts need humility.

I was interested in what was said earlier—that there are certain things that have got to be done, and done quickly. But what struck me was the *number* of things that are urgent, and in all cases have to be done—we do not want pollution, we do not want war, we do not want poverty. In other words, we can, with humility, attend to shaping positively the future, so let us address ourselves to negotiating those things that have to be cured. After all, protoman goes back four million years, and I suppose that with any kind of luck we too could last some millions of years. Therefore, there is a lot of time for us to reform, perhaps hundreds or thousands of years, but the real danger is that we will poison the earth, or that we will blow ourselves up in a global war.

These are the things that demand immediate, urgent attention. We must choose the essential things, the priorities; and God bless clearing up the litter.

In my order of priorities: poverty, certainly; pollution, certainly; overpopulation, certainly. It is not easy to generalize about these problems, but above all in importance is war.

Hence, I come back to what was four years ago one of the specific objectives of this Academy. I have a great interest in saying what to my mind takes a high priority in the essential question of selling what are going to be our priorities. We abolished slavery long ago, but how in heaven's name do we abolish war? As a member of the Pugwash group, I am not terribly confident —except in terms of little black boxes. I am frank to say that my own conclusions tend to be simple; if we can solve the problem in terms of regions, then maybe we can solve it in global terms within, at least, the life of our children.

Let us address ourselves to regionalism. If we can create a world code, I am sure we would all be in favor of it, and in favor even of what has been hopefully described as a big bang in democracy; we have to have big bangs in order to impress the politicians, so let us organize a big bang, but don't let us overestimate what a big bang can do. I say that idealogical perils are an error. I do not attach great importance to idealogical differences. I think that in time people may recite the same words, but they do not mean the same thing. As was said this afternoon, the issues tend to be those of power rather than those of variety of ideologies.

The final question I want to raise is, How are we to go about this? We do require, if Professor McDougal will permit me, interdisciplinary studies. I am not going to overestimate them, but I think that the anthropologists, psychologists, and others have contributions to make. (As a political scientist, I would allow the lawyers in on only the very central discussions, because there tend to be problems of sovereignty, and, when all is said and done, problems of sovereignty are problems of interdependence).

Aggressiveness, yes. I submit we should attend to and study aggressiveness as well as self-protection.

I am not asking that the same amount be spent on this kind of research that is spent on defense—that is nonsense. I am in favor of the astronauts and I am not in favor of cutting off all money for the astronauts and devoting it to the study of peace. But I *am* saying that a certain proportion of the money being spent on the astronaut ventures could properly be spent in a study of peace and war. Although I feel that I am against all pollution, the major pollution is perhaps that of global war, and in touching on global war, I hope that we go to the professional bodies, the global people who have only allocated economics, and not the other studies of a means to achieve peace. This is what we have to direct our attention to.

TAYLOR: Coming from an organization that deals mainly in practicalities and hardly has any time to deal in concepts, I had a certain sense of unreality this afternoon when listening to the discussants. On the other hand, I can see the thrust and concern of the people who have spoken here on the various factors that relate to each other. Like everybody else, I have noticed the deluge of concern that has washed over countries and gone into other areas of the world as well as over the deteriorating environment.

As a matter of fact, it has reflected itself even in the Congress of the United States to the point where the printers are working overtime in the General Printing Office. There were 8,000 bills introduced in the 91st Congress dealing with one aspect or another of the environment. The noise and deluge

of printing is immense. Whether or not substance comes out of it is another question.

Over a period of years in this field I have noticed—and I cannot speak for other nations of the world—that we as Americans are motivated more by crisis than we are by long-term considerations. Let me give you a couple of examples of the field in which I am particularly involved at this moment, the field of health and safety in the United States.

For years, coal miners have been dying in dusty depths without anyone really caring. Then there would be a mine disaster, there would be a Congressional hearing, somebody would say something ought to be done about it, the boards would be appointed, and in the meantime the spectacular disaster would become a past memory, and unnoticed thousands of miners would be slowly deprived of their health by pneumoconiosis. These problems never hit the newspapers, because the miners die or are disabled quietly.

In 1968 there was a major disaster at Farmington, W. Va., in which some 70-odd people were killed. This happened to come just at the right moment, the outcome of which was the enactment of the Coal Mine Safety Act. It is my opinion that had there not been an accident, we never would have got that legislation. We had another situation involving a smaller number of people, notably the underground uranium miners who mine ore on the plateaus in Colorado, Wyoming, and Utah; this is a work force that has never totaled more than 6,000 people. Some very dedicated epidemiologists with the U. S. Public Health Service finally determined that anywhere from 600 to 1,000 of these people would die—many of them had already—as a result of the inhalation of gas. It was not until we broke the story in the newspaper that something was done about it. Finally, a strong standard was adopted by the Secretary of Labor against the institutional objections of the Atomic Energy Commission, the Joint Atomic Energy Committee—all of whom have this problem, which is perhaps not true in other countries but is true of the development of nuclear energy in this country; that is, the AEC has the responsibility for both development and regulation of the use of this resource.

As a result, it is uranium development that has the front page, and the tail end of the stick is the protection of workers, although it must be admitted, frankly, that the AEC has been more assiduous in protecting its workers from ionizing radiation and has had a smaller number of accidents in their operations; this crisis affects not only population exposure, but exposures of workers as well, an illustration of the built-in entrenchment of government organizations and private business against change for regulation because it might cause an unbalance or "restriction" on the operation of existing institutions.

Two professors who have been working for the Atomic Energy Commission, Dr. Gofman and Dr. Tamplin, have published a monograph (and have enlarged on it) that indicates that existing norms for exposure of the general population in the United States, if continued at the present level, would result in anywhere up to 10,000 to 30,000 more cases of leukemia. They recommend, therefore, that the population exposure norms set by the Federal Radiation Council be strengthened by a factor of ten. If this is done, workers who are exposed on the job to ionizing radiation, who receive ten times as much as the norms allowed for the general population, would therefore, if this theory is tenable and succeeds in holding its own in scientific debate, come in and ask that every establishment using ionizing radiation, strengthen their norms by a factor of ten.

I was approached by a representative of the Atomic Energy Commission and asked what the position of the AFL-CIO Committee of Safety and Occupational Health would be. I do not make policy, I merely suggest it. I am a staff man and not a mover and shaker. But I suggested to him that we had had an opportunity to review, in a kind of a quick way, both the Gofman and the Tamplin papers, and the response of the AEC. To a certain extent we found AEC's response self-serving. But I suggested that it might be an excellent idea to put the problem in the form of a debate before some scientific body that could make a conclusion as to the merits of the argument, so that it would not drag on and be used politically and otherwise. I suggested that such improper use would obscure an issue that, if it is as these two gentlemen say, would result not only in excessive leukemia and other types of disease caused by radioactivity to the general populations, but would enormously increase the casualties to our workers. The rejoinder to this was that these two men were crazy and the AEC would not dignify them by appearing on the same platform with them. I cannot understand this attitude. Either they are right or they are not. If they are right, they should not be afraid to stand up and be counted, and if no, then they ought to admit it and say "O.K., let us consider this." Fortunately, the then Secretary Finch, as Chairman of the Federal Radiation Council, which is an interagency group, had agreed to review all the existing views on the question, and perhaps something positive will come out of it. But in the meantime, the pressure from industry and the joint committee and the pressure from AEC is to keep things as they are.

The reason I mention this is that if there is anything that is needed right now in the whole environmental field, including the work environment to which I addressed myself, it is unbiased research. At the time when the United States and the medical profession were unable to bring themselves, because of pressure of the coal-mining industry, to say that there was such a thing as coal miner's pneumoconiosis, the English had already determined this and had been doing something about it since the 1930s. It wasn't until 1968 that, finally, the industrial medical profession and the Public Health Service came around to admitting that people were dying in the coal mines simply because the coal dust in their lungs was killing them off. The medical profession in the United States will not recognize that pneumoconiosis is a disease, but they have recognized it in England; they have recognized it for a long time.

I would hope, in conclusion, that this is not another gathering where we talk among ourselves and say, "Here are all the considerations." We have talked environmental pollution for years. The first study that was made in the administration of Teddy Roosevelt, the National Conservation Commission in 1908, called for abatement of pollution. Pollution in the work place is something that apparently is keyed into the general environmental picture, yet 75 million people in this country are exposed to every kind of hazard in the world.

When I was a kid, living in Idaho, I was always told that bad weather was manufactured in Alberta, Canada, and then it all came to the United States. The most environmental bad weather is manufactured in the work places and other industrial places of this nation. We have to realize that the social consequences of this technology are something we are going to have to come to grips with. We all stand outside the decision-making area, but all of us are going to have to combine and make our voices heard; otherwise we will be an incestuous group that publishes papers, and that is the end of it.

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OBJECTIVITY IN AN INTERNATIONAL COMMUNICATIVE SYSTEM

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In a publication of the Science Council of Canada, attention was drawn to an important problem in the field of international broadcasting, the problem of securing objectivity where those in charge of a global satellite communications system might have conflicting interests or would need to declare "interest." It appears unavoidable under actual conditions that a conflict of interest will arise. There is great skepticism about the ability of COMSAT (the managing corporation) to maintain an objective point of view when political or economic interests of the United States or other participating parties are at stake. (*A Space Program for Canada,* Par. 102, p. 29, July, 1967)

The importance of the problem here briefly alluded to hardly needs stressing. If a healthy atmosphere in international relations is to come about, if international law is ever to serve as a peace-making force or, at any rate, to sweeten international relations, more and more reliance must be placed on a consensus of opinion among men of good will in all countries and among all peoples. Such consensus is indispensable. There can be no substitute for it if the world is not to be tragically dominated by force. Such consensus clearly needs to be based on an unassailable statement of the facts. If the facts can be fully ascertained, thinkers, politicians, and lawyers can proceed to suggest viable solutions whatever the problem and even when the situation seems desparate. But if the facts are distorted, even unintentionally, policies will prove impracticable and great harm may result.

An attempt will be made here to point out some of the more obvious difficulties in the way of securing reliable objective assessments in an international communications system, more especially in the field of international relations.

At first it might seem that television has worsened rather than bettered the attempts of scientists and others to produce unbiased and unprejudiced pointers to action. The reasons seem to be as follows: Television, broadly speaking, can present only those aspects of a question that can be represented pictorially, televised speeches can, of course, give useful guidance, but their impact is hardly comparable. An example from public controversy: Questions are raised as to whether heart transplants are desirable or objectionable. Photographs of surgeons, patients, hospitals, and the rest; flashes from the Italian press, "Goodbye Brave Blaiberg"; photogenic relatives; and, for good measure, portraits of the colored family from whom the donor is supposed to have come, throw no light whatever on the ethical and other problems. Indeed, it could be argued that such pictures only deflect judgment. The war pictures from Biafra might well be cited in this connection.

The simplest event—a motorcar collision or rock-climbing accident—can be viewed in as many different ways as there are observers. What range of

attitudes will ensure healthy broadcasting? In the case of newspapers, a rough and ready determinant of range is provided by the number of political parties, not overlooking the special interests of women readers. In the case of books, the obviously much wider range narrows when the group of potential buyers is too small to compensate publication. In the case of mass communications, there is little to go by, except possibly the hazard of so-called market research statistics, which in effect means attitudes habitual for the Many, ruling out the more sophisticated approach of the Few. The lowest common denominator of public sentiment must then determine the range of possible attitudes. Because the Many can be wrong, TV may conceivably, at times, be pandering to the wrongheaded. The danger must not be exaggerated, but it seems unarguable that, no matter how objective the control of communications systems, by the very nature of the medium, public opinion is not necessarily a reliable guide to action. Extreme caution is called for, though there is no need to deprecate any attempt to raise popular standards or the search for means of rendering TV and broadcasting a more impartial or objective channel of information and opinion. In the most advanced democracies, what the public can take limits the practicability of the specialists' most brilliant proposals.

A more insidious danger, perhaps, lies in the inveterate veering of public sympathies and attitudes. The ancient Athenians may have been peculiarly volatile; the modern journalist who trades in impressions first, facts afterwards, is all too often just a weathercock. The common idea that newspaper attitudes are dictated by government policy may have a measure of truth in some of the free democracies. But, apart from the idiosyncracies of newspaper proprietors, such attitudes are much more likely to be traceable to the journalistic weathercock. Popular sympathies have veered around, and so have the journalist's. And when was *semper aliquid novi* not a peculiarity of public appetite? If, in ancient Athens, the source was thought to be the Piraeus, just as jokes that go the around in England are taken to come from the Stock Exchange, these shifts of opinion, this hankering after something, anything different, is usually to be associated with a particular place. If a universal communications system will ever be possible, it might well be equally removed from seaport novelties and metropolitan intransigence.

A further difficulty needs pointing out. It can hardly be denied that the very different systems of logic prevalent among the races of mankind militate against a common attitude among scientists and thinkers of varying racial origins. However, working together in a universal communications system should eventually overcome the effects of such differences, no matter how deeply ingrained. If Japan can adopt Western procedures based ultimately on Aristotelian logic, there is no reason why China should not follow suit, reluctant though she has shown herself to emulate Japan in this respect. If Indian logic can ignore the law of contradiction and Indian judges must sit through dreary hours of self-destructive rhetoric, that is no reason why administrators from India need be under similar disability. Jewish thinkers are likely to tolerate somewhat cavalierly national pretensions and aspirations (other, of course, than their own) but, for all that, can be realistic. Molehills must not be made into mountains. In the course of time, the most intractable terrain can be slowed.

Varying degrees of development and civilization must be envisioned for a long time to come. Over large parts of the globe, the distinction first drawn by the ancient Greeks, and an integral element in the thinking of Western

peoples, has not yet penetrated; the distinction between fact and fancy, real thinking and wishful thinking. Lying propaganda is thought to serve the purposes of interested governments, but, as in the more developed countries, the public is given what it is supposed to want. If, according to the Arab proverb, "It is good to tell the truth but better to speak of the date palms," stories of the date-palms variety will be embroidered *ad infinitum*. How sane policies can be generated in such a climate of opinion is anyone's guess. Here, surely, is scope and, ultimately, success for the progressive elements in a truly objective communications system.

Difficulties need not be exaggerated. Scientists have shown an encouraging degree of cooperation in their own affairs, despite the overwhelming requirements of government service. Journalists can be found who, despite the difficulties of their calling, especially the pitifully short time available for checking first impressions, strive to be servants of the truth. The integrity of neither scientist nor journalist need be called in quesiton. Ingrained habits of mind, the idols (of the cave and the rest) of which Francis Bacon spoke, are much more likely to hamper those in charge of the system to begin with. None of the drawbacks here alluded to need be a source of discouragement. The real obstacle is more likely to be lack of will among those who alone can put such a system as is here envisaged into effect. The academic world can do its part in showing its feasibility, and so break down opposition arising from misunderstanding, timidity, or inertia. Preparatory studies can be initiated and carried through. Initiative surely lies with the academic world.

NEW TASKS FOR THE UNITED NATIONS—THE ENVIRONMENT, POPULATION, SPACE, AND SEABEDS *

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The invitation to contribute on "New Tasks for the United Nations" is gratifying and challenging. I believe that in its second quarter century the U.N. should devote increasing attention to a cluster of interrelated problems and opportunities that it hardly noticed for most of its first 25 years. These are areas that the accelerating advances of science and technology have made vitally important and where cooperative action through the U.N. can serve the interests of all men regardless of national, ideological, or racial differences. I have selected four of these areas: the environment, population, outer space, and natural resources (with particular attention to the seabed). There are others that could be mentioned, of course, but these are four of the "new tasks" that were my particular preoccupations during my service as Deputy Assistant Secretary of State for International Organization Affairs from 1961 to 1965 and that continue to engage my attention now that I have returned to private life.

However, I would first sound one note of caution. In our preoccupation with these glamorous "new tasks," let us not forget the U.N.'s "old tasks"—those absolutely fundamental responsibilities given the U.N. in its Charter—the promotion of peace, economic development, and human rights. It is on these questions that the U.N.'s performance will be judged by the people of the world—and rightly so. "Involving the U.N. in new tasks," I fear, is for some people a euphemism or an excuse for downgrading its role as a peace-keeping agency.

In this paper, I will reduce exposition and historical background to the minimum, focusing in each case on an essential question: what, exactly should the U.N. do about it?

The Environment

Our new concern with the environment has focused so far on domestic problems. We have largely neglected the international dimension. But now we are finally beginning a systematic look at our global environment in a new U.N. committee preparing for a world conference in Stockholm in 1972.

A U.N. response to the environmental challenge is long overdue. Although some measures to deal with the environment can be taken by individual nations, there are resources that do not belong entirely to any one nation—the sea, certain lakes and rivers, migratory animals—and whose effective management requires international cooperation. Even management of the

* Based on a statement before the Subcommittee on International Organizations and Movements, Committee on Foreign Affairs, Wednesday, March 4, 1970.

environment with the confines of a single nation may benefit from the sharing of national experience.

Moreover, we are finally beginning to recognize that how a nation deals with its national environment is no longer its own business and nobody else's. We are beginning to comprehend the unity of the world's ecological system, which means that all nations may be affected by how any one nation treats its air, water, and land.

We are gradually awakening to the realization that all mankind depends on the same scarce and relatively shrinking resource pool, and, therefore, has an interest in the wise husbanding of resources wherever they may be located. And business firms around the world are beginning to argue that they cannot accept the additional costs of antipollution measures unless their overseas competitors do the same.

For all these reasons, the international community will be increasingly involved in environmental issues—even those that have hitherto been regarded as "domestic." Indeed, the most powerful impetus to world order may no longer be the threat of nuclear war but, rather, the urgent necessity of new transnational measures to protect the global environment.

President Kennedy asked the General Assembly in 1963 for a U.N. effort to deal with environmental problems—but nobody was listening. Although President Nixon mentioned the environment in his address to the Assembly last fall, his only proposals for international action have been made in NATO. As an organization of limited membership whose principal function is military defense, NATO is not well suited to be the centerpiece of our effort in this field.

The global environment concerns all nations, regardless of national, ideological, or racial differences. Some work on the environment can be usefully undertaken in regional agencies like OECD, but a universal problem needs a universal system of organizations to deal with it. The U.N. system, including its regional commissions and Specialized Agencies, is the nearest thing we have to a universal system. The Stockholm Conference provides an additional reason to make it more universal by admitting mainland China and divided states. At the very least, the U.N. should invite the Peking régime, the two Germanies, the two Vietnams, and the two Koreas to participate in the Stockholm meeting.

The U.N. system, of course, is already involved in environmental problems. Important work has been done in the International Maritime Consultative Organization, for example, on oil pollution in the seas. UNESCO, the World Health Organization, the Food and Agriculture Organization, the International Atomic Energy Agency, and the International Oceanographic Commission, to give only a few examples, have all had a piece of the environmental "action."

What more can the U.N. system do about environmental problems?

To begin with, it could undertake a massive program to educate the world's people, particularly political leaders, on the problems of the environment; could sponsor joint research efforts and studies; and could finance the training of specialists to handle different environmental problems.

It could organize a worldwide observation network, using observation satellites and other new technology, to monitor the world's environment on a continuing basis, and it could operate a service for the evaluation and dissemination of this information for all nations.

It could encourage the negotiation of international agreements providing for firm antipollution and other environmental commitments so that nations and industries accepting their environmental responsibilities suffer no competitive disadvantage in international trade.

It could insure that multilateral aid programs are carried forward with due regard for their environmental implications, and could encourage the application of environmental safeguards in bilateral aid. (Downstream erosion from the Aswan Dam, we now discover, may wash away as much productive farm land as is opened by the new irrigation systems around Lake Nasser.)

Finally, it could establish a U.N. Program for the World Heritage, including scenic, historic, and natural resources now in danger of destruction and whose survival is a matter of concern to all mankind.

Obviously, each nation should be free to decide whether to nominate a property within its territory for inclusion in the Program. At the same time, the community of nations should be free to decide whether to accept it.

Countries whose resources were included in the Program would gain the advantage of international advice and financial aid in their development, with consequent benefits to their economies as a whole. And the world community would be in a position to safeguard unique and irreplaceable resources—Venice, Angkor Wat, some of the great wildlife reserves of Africa—in which all mankind has a common interest.

If the U.N. is to act effectively on environmental problems, a central group of distinguished scientists should be established under the Economic and Social Council to evaluate and coordinate the work of the different U.N. agencies active in this area. The historic pattern of functional specialization contains the danger that ecological interrelationships may not be adequately considered. For example, FAO may vote, as it recently did, to continue use of DDT; but this question needs to be looked at by a group whose thinking is not mainly centered on agricultural productivity. An "overview" committee of experts could take a broader view in evaluating the implications for the environment of new as well as existing scientific discoveries.

Population

We have all heard a great deal during the last few years about the world population problem. Instead of repeating it, let me just state in one paragraph what I take to be the essential point:

Present rates of population growth in most developing countries of the world—and some developed countries as well—will, if continued, destroy all our hopes for meaningful increases in individual living standards. Worse still, world population trends are dangerously overloading the natural environment, threatening political stability, and breeding tensions that increasingly erupt into violence. The rate of world population growth is now so great—its consequences are so grave—that this may be the last generation that has the opportunity to limit population growth on the basis of free choice. If we do not make voluntary family planning possible in this generation, we will make compulsory family planning inevitable in future generations.

For the first 17 years of its existence, the U.N. did nothing about the population problem except for statistical and demographic activity. It was only in December, 1962, that the General Assembly, at the initiative of the Swedish Government, passed its first resolution on the subject. In a speech approved by President Kennedy, I told the Assembly on that occasion that the United States favored U.N. action to deal with the population problem and that we were prepared to "help other countries, upon request, to find potential sources of information and assistance on ways and means of dealing with population problems." It is a measure of how backward we were on population in those days that this statement was regarded as revolutionary.

Both the United States and the United Nations have come a long way since 1962. We have begun a major effort to make family planning services available at home, and we have made increasing funds for family planning available in our foreign aid program. The General Assembly, the Economic and Social Council, the Economic Commission for Asia and the Far East, the United Nations Children's Fund, the World Health Organization, and UNESCO have all established legislative mandates for action by their executive leadership. The World Bank under Robert McNamara has also moved swiftly into the population field.

The Secretary-General has established a Trust Fund for Population under the U.N. Development Program that is available to support the population activities of the U.N. and the Specialized Agencies. The Administrator of that Program has appointed a senior official to be in charge of the Fund. The U.N.'s own Population Division has been strengthened. The U.N. has sent missions to India, Pakistan, Colombia, and various parts of Africa and has recruited Population Program officers who are now in the field in Asia, Africa, and Latin America.

All this represents progress, and the United States played a leading role in it. Yet the ratio of talk to action on population remains distressingly high. The world still lacks a wholly satisfactory, economical contraceptive well adapted to the needs of the developing countries. Few developing countries yet have effective nationwide family planning programs. Only a small fraction of the U.N.'s funds are earmarked for population programs.

In a sensitive area like family planning, the case for a multilateral approach is particularly compelling. International agencies can help promote a broad consensus on the nature of the population problem and on what ought to be done about it. They can help countries share responsibility for taking controversial steps that may be opposed by particular domestic interests. They can help prevent family planning from becoming a cold-war issue involving political ideologies, or a subject of disagreement between national or racial groups. The United Nations and its family of agencies are thus a logical place for increased efforts to deal with the population problem.

In May, 1969, a citizen's panel of the United Nations Association chaired by John D. Rockefeller, III, on which I had the privilege of serving, issued a report entitled "World Population—A Challenge to the United Nations and Its System of Agencies." Its most important recommendations were:

1) The present Trust Fund for Population should be increased to at least $100 million in voluntary contributions per year (an increase of more than tenfold over present levels).

2) A Commissioner for Population should be established to administer the Fund, implement population projects financed from the Fund, and represent the U.N. in dealings with governments and in intergovernmental forums concerned with population.

3) The Commissioner for Population should be prepared to sponsor or support projects extending across the whole spectrum of population and family-planning programs, such as the training of medical and paramedical personnel; family-planning components of health facilities; the use of mass-communication techniques; the manufacture of contraceptive materials; and the establishment of special population study centers as well as ongoing statistical census and demographic work.

4) The Commissioner for Population should devote substantial resources from the Population Trust Fund to the support of research into better methods of fertility control, into the operation of family-planning programs, and into the relationship between population policy and development policy. (I believe the World Bank should also be encouraged to devote substantial sums to this purpose.)

I have estimated elsewhere (*The Global Partnership*, p. 337) that the cost of providing family-planning services to all the women in the world who want them would be something like $2 billion a year. This offers some notion of the magnitude of the task before us. Obviously the U.N. cannot be a substitute for national efforts, but it can encourage them and provide essential advice, technology, and resources where these are wanted and needed.

Outer Space

The case for using the United Nations system as a framework for space cooperation is a powerful one. It is in the interest of all countries, whatever their ideology, that space and celestial bodies not be subjected to competing national claims, that cooperative experiments be undertaken and information exchanged, that worldwide weather services be developed, and that communications among nations be improved. U.N. meetings have served to emphasize this common interest to Soviet scientists and technical experts and, through them, to the Soviet Government. While the United Nations and its Specialized Agencies are not the only institutions to promote cooperation, they do help to put cooperation between the United States and the Soviet Union into a broader framework that recognizes the interests of other countries. And, because the success of the U.N. programs is enhanced by U.S.-Soviet cooperation, the interest of other countries in such cooperation that is manifested in U.N. meetings has helped to stimulate affirmative Soviet actions.

For the United States, cooperative efforts are an absolute necessity if certain space activities are to be successful. In weather and communications, for example, the technology of the United States can yield maximum dividends to its own people and to others only if many nations join in allocating radio frequencies, in tracking and communicating with space vehicles, and in placing necessary ground installations on their territories. For certain activities, bilateral arrangements are most suitable; for others, cooperative projects may be easier to achieve if they are multilateral and bear United Nations endorsement.

It is not too much to hope that, beyond these benefits, cooperative space ventures will strengthen the sense of world community. The new responsibilities of the United Nations for promoting scientific cooperation and information exchange and for assisting in the development of worldwide weather and communication services cannot fail to strengthen the organization as a force for peace by binding its members to it through ties of common interest.

These are some of the considerations that led the United States to propose a comprehensive program of space cooperation under U.N. auspices in 1961. The result of this initiative was the Space Treaty, the Treaty on Rescue and Return of Astronauts, the World Weather Watch, and certain modest U.N. activities of technical assistance and information exchange in the space field.

Frankly, I wish our cooperative efforts through the U.N. could have been more ambitious. In his address to the General Assembly of September 20, 1963, President Kennedy said:

> In a field where the United States and the Soviet Union have a special capacity—the field of space—there is room for new cooperation, for further joint efforts in the regulation and exploration of space. I include among these possibilities a joint expedition to the moon. . . . Why . . . should the United States and the Soviet Union, in preparing for such expeditions, become involved in immense duplications of research, construction and expenditure? Surely we should explore whether the scientists and astronauts of our two countries—indeed, of all the world—cannot work together in the conquest of space, sending some day in this decade to the moon not the representatives of a single nation but the representatives of all of our countries.

Unfortunately, the Soviet Union did not respond to this invitation, and the Johnson Administration made no serious effort to revive it. Thus, for the better part of a decade, we engaged with the Russians in a race to the moon. This race entailed a massive duplication of effort and a substantial waste of expenditure on both sides. Moreover, important opportunities for the enhancement of international cooperation were lost.

With the brilliantly successful landing of our astronauts on the moon in July, 1969, the race ended. It is too late to convert this race into a cooperative venture in space exploration on behalf of all mankind, but it is not too late to try a new approach in the next phase of space exploration. A first step in this direction could be the creation of a United Nations Space Institute. The Institute, which might be located in Geneva or Vienna, would be a center for the cooperative planning of space exploration in which all U.N. members could be invited to take part.

Scientists from the United States and the Soviet Union and other countries could work together on such subjects as the medical problems of manned space flight. They could recommend a set of common priorities for mankind in space and a specific timeable for space missions.

Instead of both the United States and the Soviet Union undertaking landings on Mars and Venus, for example, they could divide responsibility for instrumented landings on different planets. Such activities would be considered part of a total U.N. program, and every opportunity would be found to let other countries participate in their preparation and in the sharing of the information. We could also establish a United Nations Space Station, a true joint venture of mankind in what most authorities now agree is the most important space task of the next decade.

Joint ventures in space between ourselves and the Soviets have hitherto been regarded as impractical. It has been said that the presence of Soviet astronauts and Soviet scientists at American launching sites would give them access to our rocket technology and thus prejudice our national security—and vice versa. But technology now offers a way around this problem. Both we and the Soviets have developed the art of rendezvous and docking in space. We and they could launch elements of a space station that could be assembled

in outer space. The equipment could be agreed on in advance to assure compatibility. The astronauts—drawn not only from the United States and the Soviet Union but from other U.N. members—could be trained together at the U.N. Space Institute.

When other U.N. members—for example, Japan and European countries—develop sufficient space capabilities, they could be invited to launch additional modules for the space station. In the meantime, their scientific abilities could be used to the full in designing and producing the equipment to be launched by the U.S. and the U.S.S.R.

A U.N. space station could be an orbiting astronomical laboratory, gathering information about our solar system and the universe beyond. It could also be used for practical earth applications—for weather forecasting, observing ice and snow accumulations, mapping ocean currents, monitoring the environment, and locating mineral deposits. One day it might help patrol troubled borders and verify arms-control agreements.

Such a cooperative space program could serve the enlightened self-interest of all. The sharing of the costs of space exploration and the adopting of a space timetable geared to scientific cooperation rather than to political competition could save billions of dollars that the U.S. and the Soviet Union could devote to pressing domestic needs. The non-space powers, including the less developed countries, could participate more fully in space exploration. Every country would have access to information gained from space activities—for example, the discovery of mineral deposits made possible by observation from a space station. Finally—and by no means least important—significant political benefits could be realized in close U.S.-Soviet cooperation and a stronger United Nations.

The other aspect of space cooperation that should be mentioned here is cooperation in the use of new technology in space communications. In the 1970s, the International Telecommunication Satellite Consortium (Intelsat) will be further developing its global network of space communications, making use of huge Intelsat satellites with 5,000 voice channels, enough for 12 TV broadcasts.

Present technology makes use of *point-to-point satellites*, in which messages are sent from one ground station through the satellite to another station on the ground. But the 1970s will usher in the use of *broadcast satellites*, which can transmit radio or TV to thousands of community or village receivers simultaneously, and eventually into home radio or TV sets over an area of a million square miles. The difference between broadcast satellites and point-to-point satellites is both economic and political. Because they bypass the need for expensive ground relay systems, broadcast satellites may be cheaper and more effective than alternative means of communication for reaching large areas, particularly in such less developed countries as India, Pakistan, Indonesia, and Brazil.

Broadcast satellites also raise the possibility of broadcasting to the citizens of a country without the consent and perhaps even over the opposition of its Government. The prospect of bypassing national broadcasting networks has alarmed some people. In the corridors of the United Nations, one delegate from a less developed country has remarked: "The heads of foreign states will soon be able to address my people, but our own President will not be able to do so. What is the U.N. going to do to help us?"

Of course, it can be argued that space broadcasting is merely an extension

of the broadcasting on short wave now carried on by such agencies as the Voice of America, the British Broadcasting Corporation, and Radio Moscow. It is, however, a significant extension. Unlike short-wage boardcasting, radio programs broadcast from space will be indistinguishable, so far as quality of reception is concerned, from radio programs broadcast locally. And television programs sent from space will have a substantially greater psychological impact than short-wave radio broadcasts.

The heart of the political problem can be summed up thus: Countries with no immediate prospect of carrying on space broadcasting fear that the United States, the Soviet Union, or possibly a joint European satellite authority may use this technology to send their people political or commercial messages that the governments do not like. Unless it is possible to allay the fears of such countries about uncontrolled communication with their populations and give them an interest in the use of this technology for their own benefit, the enormous potential of broadcast satellites may never be realized.

We should greatly accelerate our efforts to make satellite broadcasting available to the less developed countries to help speed their efforts at national integration and economic development. A network of community TV receivers in India, for example, could be an enormous aid in the eradication of illiteracy, the introduction of new agriculture techniques, and the encouragement of family planning. In adapting the new technology to the needs of the developing countries, maximum use should be made of the research, technical assistance, and financial resources of the U.N. system. This will mean new roles and responsibilities for agencies like UNESCO, the UNDP, the International Telecommunication Union, and the World Bank.

Intelsat should grant the U.N.'s modest request submitted to the Intelsat Conference in 1969 for free use of its facilities to handle the U.N.'s internal communication needs and to carry radio and TV programs produced at the U.N. The U.N.'s needs could be met with one percent of the channel capacity available on the Intelsat IV satellites that will soon be available. This would be a good "public relations" investment for Intelsat and would have no adverse effect on the profitability of the system.

The U.N.'s request to meet its internal communication needs is extremely modest—two telephone links from New York to Geneva, one each with its five major regional centers, and one each with its peacekeeping operations in Cyprus, the Middle East, and Kashmir.

Free use of satellites would help meet the U.N.'s urgent need for better communications to manage its worldwide operation. During the Middle East crisis of June, 1967, the U.N. was seriously handicapped by its inadequate communications arrangements: the Secretary-General and his staff did not know what was going on in the area until many hours later. The U.N. will never be an adequate peace-keeping agency until it has better communications facilities at its disposal.

As the U.N. document submitted in 1969 to the Intelsat Conference put it: "Under present circumstances the U.N. is taking risks which for long have been regarded as unacceptable by governments for their own national communications needs." Surely it would be in our own and the general interest to give the U.N. a secure, reliable and cost-free method of communication for its operations in the service of humanity.

Free use of Intelsat facilities for TV and radio programs produced at U.N. headquarters would also be in the general interest, because it would encourage

the dissemination of such programs now greatly inhibited by the high cost. It is a paradox that the only area of the world that, as a practical matter, can get simultaneous TV transmission from the United Nations today is North America. By the accident of the U.N.'s location in this hemisphere, our people can get the U.N. immediately on TV, when there is a crisis, or a Security Council debate, but the rest of the world cannot. This seems to me an element of discrimination or inequality that is most unfortunate. We want to keep the U.N. in the United States, but, surely, we want to make it possible for other nations and other peoples to know what is going on at the U.N.

It serves our enlightened self-interest to encourage the distribution of programs that may give people around the world a different point of view from what they normally hear on their own national TV or radio networks. Thirteen Senators and 44 members of the House of Representatives from both parties wrote to the Secretary of State supporting the recommendation of the Foreign Affairs Subcommittee that "the United States should support reasonable requests by the Secretary-General of the United Nations for free use of Intelsat facilities." Yet elements within the United States Government are still resisting this proposal. Here, I am afraid, is a practical example of how our talk of "new tasks" for the U.N. has not yet been matched by our actions.

Looking beyond the specific questions of free use of Intelsat facilities, there are many things that could be done to use satellite communication as an instrument for the building of a better world order. The U.N.'s Radio and Visual Services Department, now budgeted at the totally inadequate figure of $2 million, could greatly expand its work. The General Assembly could adopt a resolution:

1) Providing for an annual "State of the World" TV and radio address by the Secretary-General, which U.N. members would be asked to carry on their TV and radio networks, and

2) Urging U.N. members to devote at least one hour a week of prime TV time (or radio time where TV does not exist) to programs produced at U.N. headquarters.

The Radio and Visual Services Department of the U.N. Office of Public Information has already demonstrated its capacity to produce such programs —some showing the executive activities of the U.N. at headquarters and in the field, others giving representative and balanced highlights of U.N. debates.

Many U.N. members provide no radio or TV reporting to their populations on U.N. activities. Many allow their people to hear only those parts of U.N. debates that represent their national point of view. One hour a week of U.N.-produced programs, including highlights of debates, could be a useful corrective. It would surely be a great step toward peace if the people of Egypt and Israel, for example, could have even a few minutes' exposure per week to another view of the Middle East problem.

We should have no illusions that those U.N. members with tightly closed national societies would immediately implement such a resolution. But a resolution of this kind might well mobilize international and domestic opinion upon them to implement it after a number of years. At the very least, it would reveal very clearly which countries are really prepared to take practical steps toward international understanding and a more effective United Nations—

and which are not prepared to do so. The United States should take the lead in demonstrating the possibilities of promoting international understanding through communication satellites. We should give the Soviet leaders the opportunity to talk directly to the American people at regular intervals on TV in return for the same privilege for our leaders in the Soviet Union.

The possibilities opened up by communication satellites for world development and understanding are truly exciting. They provide an opportunity to create more open national societies, which are not merely desirable for their own sake but are essential ingredients of a peaceful international community. To make use of this opportunity, however, we will need to display the same ingenuity in political and social arrangements that we have already demonstrated in the technical sphere.

Natural Resources—The Seabed

The discovery and wise development of natural resources is a key element in efforts to raise living standards in the less developed areas of the world. The United Nations system has already done much valuable work in this field. Recently, for example, U.N. experts executing a project for the UNDP found uranium in Somalia, and the Government of Somalia is already making arrangements with foreign industry for the extraction of this rich resource on a mutually beneficial basis. Yet, the potentiality of the U.N. in the field of natural resources is even greater than has been realized so far. Much more could be done through the U.N. system to help the developing countries discover new resources, train resource technicians and managers, and integrate national resource planning with manpower development programs, capital requirements, and national and regional planning generally.

It is tragic that U.N. budgetary restrictions, for which the United States is partly responsible, are now bearing with particular severity on the work of the resources section of the U.N. Secretariat and are generally limiting the U.N.'s work in the resource field. This is a classic example of penny-wise pound-foolishness, because a few million dollars in U.N. activity here can yield resource discoveries worth tens of millions in revenues to the governments of the less developed countries as well as to our own.

Indeed, the potentiality for self-financing of the U.N.'s work in the resource field has not been sufficiently recognized. Why should not the U.N. receive a "finder's fee" when it discovers resources in a developing country? The funds paid by the developing country out of the new revenues resulting from the resource find could finance U.N. resource surveys in other developing countries.

The major resource issue before the U.N. today is that of the seabed. There are two key questions for the seabed: First, what should be the width of the continental shelf in which a coastal state has exclusive mineral rights? Second, what kind of regime should apply to areas beyond the jurisdiction of coastal states? The failure of the United States Government to develop clear answers to these two questions has, I fear, contributed to an unfortunate polarization of views.

At one extreme, there are some U.N. members who want national jurisdiction in the seabed narrowly limited and who want the U.N. itself to carry on exploitation in the seabed beyond national jurisdiction, with most of the profits from this activity going to the less developed countries. At the other

extreme, there are some segments of our petroleum industry who want to extend national jurisdiction out to the seaward edge of the continental rise, and who oppose any kind of international regime over a part of the seabed that contains valuable resources.

The first view is clearly unrealistic. There is little in the experience of the U.N. that suggests that it could effectively discharge this kind of operating responsibility. The know-how and the technology for exploitation of the seabed is in the hands of private companies and governments, mainly our own. If the riches of the seabed are ever to get above water, adequate incentives and security of investment will have to be given those who have the ability to do the job.

The second view is not less shortsighted. The United States has only 10 percent of the world's geological continental shelf. As the world's principal resource consumer, we should not be seeking a solution that puts 90 percent of the continental shelf of the world (and a similar portion of the seabed up to the continental rise) under the exclusive jurisdiction of other countries. It is by no means clear, as some spokesman for the petroleum industry assume, that individual coastal states will be easier to deal with than an international authority.

The United States, as the country furthest advanced in seabed technology, is in a strong position to negotiate an international regime acceptable to it as well as other nations. A U.N. agency could be established to license operations by private companies, public corporations, or governments, in return for an appropriate royalty. The royalties could be channeled for world development through the World Bank and its soft-loan affiliate, the International Development Association.

The U.N. agency could be established with voting arrangements assuring an appropriate voice for all the different interests concerned—the United States and other leaders in seabed technology, developed countries, less developed countries, coastal and noncoastal states, and so on. The amount of the royalty could be fixed at a level that would provide adequate incentives for seabed production and generous amounts of new financial resources for the developing countries.

Such an international regime would be far superior in terms of our enlightened self-interest to the scramble for resources inherent in the extension of national jurisdiction to the seaward edge of the continental rise. An international regime, for one thing, would provide safeguards against wildcatting and a system for the orderly registration of claims and settlement of disputes. Most important, it would provide for international antipollution and conservation measures in a vast area of the seas that might otherwise be subject to unregulated or inadequately regulated national and private activity.

If an international regime can be worked out along these lines, the U.S. could then accept a relatively narrow boundary for the continental shelf under national jurisdiction. To be specific, the limits of national jurisdiction could be set at 200 meters depth or a lateral distance of 50 miles from the shoreline, whichever is greater.

It is obvious that the width of the boundary is inseparably bound up with the nature of the international regime. What is less obvious, but also true as a matter of practical politics, is that these questions are linked to the questions of the breadth of territorial waters and fishery rights. For example, certain Latin American countries are less well endowed with seabed resources off their coasts

but are concerned with rich off-coast fishery resources and are not likely to make agreements in the one area without satisfaction in the other. To put it more broadly, these and other states will want to trade off acceptance of a relatively narrow territorial sea boundary in return for some special recognition of their fishery interests beyond and some reasonable sharing in the benefits of seabed resources development.

For these reasons, I come to the reluctant conclusion that there will have to be one international conference to deal with all these complex law-of-the-sea questions, rather than the separate conference on the territorial sea and fisheries that the U.S. Government has been seeking. The tradeoffs are now too well and widely recognized to compartmentalize these questions. Of course, if an international conference is held, the different law-of-the-sea questions could be discussed in separate commissions, but the final compromises would be made in interrelated negotiations at the senior political level.

President Nixon put the matter clearly in his Report to the Congress on Foreign Policy:

> In addition, as man's uses of the oceans grow, international law must keep pace. The most pressing issue regarding the law of the sea is the need to achieve agreement on the breadth of the territorial sea, to head off the threat of escalating national claims over the ocean. We also believe it important to make parallel progress toward establishing an internationally agreed boundary between the continental shelf and the deep seabeds and on a regime for exploitation of deep seabed resources.

I very much hope that this statement will soon be translated into official U.S. willingness to participate in a single conference and, equally important, into a U.S. negotiating position on the questions of continental shelf boundary and international regime along the general lines suggested above.

Implications for U.S. Policy

I have tried to sketch some of the "new tasks" that could make the United Nations a much more significant force in world affairs than it has been in the past. Yet, to be completely honest, I must add that the U.N. presently suffers from serious weaknesses that restrict its capacity to undertake these tasks effectively.

One problem is that the U.N. Secretariat does not have a sufficient number of highly qualified experts to support expanded cooperation in areas like the environment, population, space, and natural resources. Another is that the U.N. is not yet organized effectively to deal with these subjects. To cope with the organizational problem, we need to press for reforms along the lines of the "capacity study" of Sir Robert Jackson in order to achieve a more unified effort by the UNDP, the Department of Economic and Social Affairs, the semi-autonomous bodies, and the Specialized Agencies. We also need to draw together the interrelated technological areas presently parceled out among different sections of the Secretariat.

At the present time, for example, outer space and seabeds are handled by the Department of Political and Security Affairs (headed by a Soviet Undersecretary) simply because these items happen to be discussed in the First (Political) Committee of the General Assembly, for which that Department is responsible. Environment and population are handled in the Department

of Economic and Social Affairs, because those subjects are dealt with in the Second (Economic) Committee.

I recommend abolishing the Special Political Committee of the Assembly, transferring its few annual items to the First Committee, and creating in its place a new Committee to handle the annual debate on the subjects I have discussed, together with other related issues of science and technology. If this were done, it would be logical to establish a new Secretariat unit handling these same issues which could serve the new Committee. It is to be hoped that governments would send as representatives to this new Committee highly qualified scientists and experts, not political figures or foreign service career officers, who usually do little more than read speeches written for them in capitals.

These points have a number of implications for U.S. policy. In recent years, the United States has fought hard against increases in the U.N. budget, and has gone so far as to join in joint representations on this subject with the Soviet Union. Because of this attitude on the budget, our delegates are in the anomalous position of saying that we favor U.N. initiatives in environment, population, outer space and other areas—provided they don't cost money. Obviously, as long as this financial attitude persists, the U.N. will not be able to attract the top-flight talent it needs, upgrade its central Secretariat, and respond as it should to the new challenges confronting it. Moreover, and this is a point frequently overlooked in Washington, the United States will be in a poor position to press for needed reforms in the U.N.—for strengthening the central U.N. machinery in relation to the agencies and for more reasonable methods of taking decisions—if it is disengaging itself from its financial responsibilities and narrowly circumscribing the conditions of its participation.

Candor compels me to note that the Congress bears some responsibility for the difficult position in which our U.N. delegation presently finds itself. Congress has cut the U.S. contributions to the U.N. Development Program to the point where the U.S. can no longer put up its traditional 40 percent of the total. Congress has required that $2.5 million of our assessed share of the regular budgets of U.N. agencies be paid in nonconvertible foreign currencies —a requirement inconsistent with the U.N. financial regulations. The United States, which has rightly complained in the past of the failure of other U.N. members to meet their fiscal responsibilities under the Charter, is now slipping into default itself.

No one questions, of course, that in the face of rising costs and pressing domestic needs we must make every effort to reduce unnecessary expenditures in the United Nations as well as elsewhere. But I cannot accept the assumption, which seems to be prevalent in the Appropriations Committees and in certain parts of the Administration, that increases in our contributions to international organizations must be limited in proportion to limitations placed on other parts of our Federal budget. Our total contributions to the U.N. system in 1969, including the Specialized Agencies and voluntary programs, amounts to about $250 million—less than the cost of the New York City Fire Department, less than one week's cost of the Vietnam war. How can we talk of having the U.N. perform bold "new tasks" if we are determined to limit our effort to this amount?

There is a related point that needs to be made. This has to do with the size of our foreign aid effort. Congress recently voted the smallest foreign aid appropriation in the program's history. President Nixon's aid request this year

is the lowest since 1956. At the very moment that other countries are moving toward the internationally agreed aid target of 1 percent of Gross National Product, the United States is moving away from it.

Unless we take measures to increase the quantity and quality of our international aid effort, I fear the political and financial basis for the "new tasks" I have outlined will not exist. This is particularly true with respect to the environment and population. Not only does action on environmental and population problems cost money that the developing countries do not have, but political resistance to efforts in these fields is likely to grow if U.S. foreign aid is static or declining. Already at the U.N. some less developed countries are charging that the new emphasis by the United States on population and the environment is a gigantic "cop-out" to justify a declining aid effort.

The "Nixon doctrine" in foreign policy states a commendable objective —that we should do less by ourselves and more in partnership with others.

I hope we will give concrete manifestation to both of these propositions, not only to the first of them.

THE ADMINISTRATION OF JUSTICE

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There is no worldwide administration of justice. In the several States of the world, justice is well- or ill-administered by national authorities. Injustice may be administered as a matter of national policy, as in South Africa and Greece. Justice may be ill-administered through inefficiencies or inabilities.

One would like to think that the United Nations could be the international administrator of justice. But the United Nations has only the powers that the Member States give to it. The General Assembly may condemn in many resolutions, but unhappily for the concept of world law, the resolutions are, by and large, merely exhortations. Who administers justice to the Namibians, to the Ibos, to the Arab refugees, to Greek prisoners?

There are, nevertheless, some standards and some devices for the international administration of justice.

* * *

One of the most firmly established rules of international law places on States the responsibility for a denial of justice to an alien. Hundreds of decisions of international tribunals have provided an abundant jurisprudence on the subject, but the definition of "denial of justice," like the definition of many other legal precepts—in both national and international law—is enshrouded in juristic disagreements. This is not the place to pronounce in favor of one or another view. Some of the opinions attached to the recent judgment of the International Court of Justice in the *Barcelona Traction* case have commented on the problem, although the Court itself did not find it necessary to reach a decision on this point. Suffice it to say that some of the difficulties with the rule have arisen from abuses of the right of diplomatic protection in eras that have long since been superseded in the practice of States.

The rule forbidding denials of justice is significant in our present context because it reveals a consensus in the international community that the administration of justice is of international concern. When charged with a denial of justice, States have never been able to seek refuge in the plea of domestic jurisdiction.

In the present stage of interstatal legal development, international law is concerned with the responsibility of States to aliens, that is, to citizens of other States. The world is still groping in the fog of outmoded sovereignty for accepted legal rules protecting that much broader range we call "human rights." Only among 16 of the States of the European Community, under the Rome Convention of 1950, establishing the European Human Rights Commission and the European Court of Human Rights, has there been full acceptance of the legal principle that a State may be held to international accountability for denying justice to its own citizens. Here, in microcosm, is indeed the international administration of justice. We note like promise of progress in the Americas.

An optimistic view hails the adoption in many national constitutions of principles embodied in the Universal Declaration of Human Rights adopted by the United Nations General Assembly in 1948. It may be true also that that Declaration inspired the Rome Convention of 1950. But incorporation in national laws or constitutions throws us back on national administration of justice, which may vary from State to State, from government to government, and from year to year.

In 1966, the General Assembly approved two Draft Covenants of Human Rights that are designed to make observance of such rights matters of international obligation. By June 1969, only 36 States had signed the two Covenants and no State had ratified either.

Numerous resolutions of organs of the United Nations have denounced the failure of the Union of South Africa to administer to the people of Namibia, for whose welfare South Africa accepted responsibility under a League of Nations Mandate. Greece hastily withdrew from the Council of Europe to forfend a widely supported move for its expulsion because of the denial of justice to many of its citizens.

Yet there is still a double standard. There is the international law standard that sets minimum requirements for the treatment of aliens in their persons and in their property. There is the test widely advocated, especially by the Latin American States, that would measure the propriety of treatment of aliens by equality with the treatment of nationals, regardless of the way in which nationals are treated. But the advocates of this latter test—developed as a defense against strong powers like the United States 50 and more years ago—would scarcely be accepted by, let us say, Mexico, as an appropriate gauge of the way Mexican citizens might be treated today in Greece or Rhodesia.

There are those in and out of South Africa who attempt to justify apartheid, but in only a few cases is the defense based on an assertion that the imposition of apartheid constitutes *justice* for nonwhite majorities. Excuses other than administration of justice were also advanced some three centuries ago to justify the obliteration of the great Inca civilization, just as in succeeding decades other indigenous peoples were sacrificed to the rapacity of "civilized" colonizers. How sardonic to express one's abhorrence for pagan practices of human sacrifice by sacrificing the practitioners!

All in all, it is a real achievement of human progress that international law has imposed and imposes responsibility for denial of justice to aliens, even though it has still fallen short of the goal of protecting all human rights. Some administration of justice is then required. By whom is this requisite justice administered?

It is (or is to be) administered by national authorities, in the first place. If justice is denied at that level, other States or the international organization of the United Nations or of regional associations may seek amends. Here one can note numerous historical instances of so-called humanitarian intervention. In response to such pressure, there may or may not be a rectification or compensation. If issues of fact or law are controverted, there may be submission to an international conciliator or to a tribunal, which, in its highest form, means the International Court of Justice.

For whose benefit is this requisite justice administered?

When the international practice developed, a century and more ago, cases involved aliens who lived abroad and were operating ranches or mines or other

enterprises; perhaps claims were advanced for their widows or surviving children. But in this materialistic world, claims were equally made for material loss by destruction or seizure of property.

Property, however, may be held either by individuals or by companies whose corporate structure throws a blanket of anonymity over the human beings who are its owners or operators. From the early days of the English common law, a greatmaster of the law, Coke, declared—quite rightly—that "corporations have no souls." From this proposition it might be said to follow that corporations have no "human right," but international law and practice have maintained the rule that they are entitled to be beneficiaries of a system of administration of justice in countries other than their own. Modern developments in acknowledging human rights even in one's own State concentrate on individual human beings, not on corporate agglomerations.

Intergovernmental procedures are slow and cumbersome. Man is an impatient animal, and the corporate person is often in an even greater hurry. So new devices are developed. Neither individuals nor the largest and most powerful companies have traditionally been admitted to stand on an equal legal plane with even minuscule States. But despite denunciations—often rather reckless but not infrequently justified—of "exploitation," economic progress throughout the world, both in old countries and in new, requires the utilization of skills, techniques, and resources. When such aids are utilized by States, disagreements are likely to arise just as they arise in relations between companies in the domestic national sphere. If collaboration is to continue, disagreements must be settled. Since 1924, the International Chamber of Commerce has maintained a Court of Arbitration in Paris; that Court has dealt with more than 2,000 disputes, many between companies and governments In 1965, the International Bank for Reconstruction and Development submitted to Governments a Convention on the Settlement of Investment Disputes between States and Nationals of Other States. Some 47 States, including the United States and the United Kingdom, have become parties to this Convention, and a dozen others have signed. But even at this level, the new organs for adjustment and settlement can act only when the parties to the dispute consent.

This is the key to the weakness of the whole international system for the administration of justice through courts. I have often been asked why the International Court of Justice has done nothing to settle the disputes between Israel and the Arab States or to end the war in Vietnam. The Court is powerless unless and until the States parties to a dispute or controversy agree to submit to its jurisdiction. The International Court of Justice is the principal judicial organ of the United Nations; the Security Council is the principal political organ. But the Security Council has no power to order States to submit a controversy to the Court; the Security Council can only recommend that they submit—and it has rarely done even that.

On the other hand, there is a way in which the International Court of Justice can be authorized to pronounce on the legal aspects of international disputes. Under the United Nations Charter, the principal organs of the United Nations and the various agencies that have been so authorized may ask the Court to render an advisory opinion. The advisory-opinion device was developed in the predecessor to the International Court of Justice, namely the Permanent Court of International Justice, which was established in 1921 as a part of the general peace organization of the League of Nations. Some then argued that it was not a *judicial* function to render opinions that were merely

advisory and not binding. But it was pointed out that in the legal system of many States of the world, and in some of the states of the United States, courts are authorized to deliver advisory opinions.

As operated in the League of Nations system, the advisory opinions were very useful. The peace treaties at the end of World War I had introduced many shifts in boundaries and many provisions to guard the rights of minorities, especially where national boundaries were changed. Disputes over the interpretation of the treaty provisions were inevitable. There was special machinery for administering justice in certain cases, but when the disputes threatened the peaceful relations between two States, resort was often had to the Council of the League. The Council developed the useful procedure (which unfortunately has not been adopted by the Security Council of the United Nations) of appointing a person known as a reporter who was asked to look into the question, to talk with the parties, and to make recommendations to the Council. He was in part fact finder, in part a mediator or conciliator. It often happened that the reporter would say to the Council: "There is involved in this dispute a variety of elements of which one is the interpretation of a few words in Article XXX of the Treaty of Peace. If you could ask the Permanent Court of International Justice to render an advisory opinion interpreting those words, it would greatly help me in bringing the matter to a solution. Meanwhile, during the time required for the Court's deliberation, I will have time to explore and seek to adjust certain other aspects of the dispute."

The Council of the League asked the Permanent Court of International Justice for 27 advisory opinions between 1922 and the outbreak of World War II, in 1939. The *Assembly* of the League of Nations also had the power to ask for advisory opinions, but although over the years it came to acquire more and more political influence, it never asked for a single advisory opinion. How different is the situation in the United Nations! The General Assembly has asked for nine advisory opinions and the Security Council has never asked for one. The requests of the General Assembly have dealt principally with what might be called constitutional questions concerning the operation of the United Nations and its organs, although some have been on the fringes at least of attempts to settle important international political questions.

When it is said that the international system for the administration of justice is so weak that it is impossible to secure a judicial ruling on such legal problems as the right of access to the Gulf of Aqaba or the rights of passage through the Suez Canal, the broad assertion is false. The Security Council or the General Assembly could have submitted such questions to the International Court of Justice for advisory opinions. They can still do so. The difficulty lies not in the unavailability of judicial machinery for the administration of justice but in the unwillingness of governments to use the machinery. Too many governments, partisan to one side of a dispute or another, are afraid of obtaining justice that may not be to the liking of one or the other party to a controversy. Better, it seems to them, to seek compromise and delay in the Micawberish hope that something favorable may turn up. This is also the principal reason why so few cases are submitted by States for actual decision by the International Court of Justice.

But it is said that advisory opinions are not binding and that they will therefore be disregarded or repudiated. The first part of the statement is

correct; the second part is not proved by experience. In the days of the League of Nations, Governments whose positions were not supported by advisory opinions of the Permanent Court of International Justice grumbled and spluttered, but generally the opinions, supported by the influence of the League Council, served as the basis for final action in settling the matter.

In the history of the United Nations one finds clear examples both ways. When the General Assembly asked, in effect, whether the Charter means what it says in Article 17—"The expenses of the Organization shall be borne by the Members as apportioned by the General Assembly"—the International Court of Justice replied, yes, States are obligated to pay the amount apportioned by the General Assembly. In that situation, two important States, the Soviet Union and France, refused to admit that the Court was correct and continued to refuse to pay amounts assessed by the General Assembly. However, the resulting situation, in terms of the financial difficulties of the United Nations, was at least no worse than it was before the Court gave its opinions, and some members of the United Nations bowed to the correctness of the Court's opinion.

Probably the most successful international administration of justice has been achieved in the limited but highly important area of labor conditions. The Constitution of the International Labor Organization formed part of the Treaty of Versailles at the end of World War I. Its preamble recites:

> Whereas the League of Nations has for its object the establishment of universal peace, and such a peace can be established only if it is based on social justice;
>
> And whereas conditions of labour exist involving such injustice, hardship and privation to large numbers of people as to produce unrest so great that the peace and harmony of the world are imperilled . . .
>
> Whereas also the failure of any nation to adopt humane conditions of labour is an obstacle in the way of other nations which desire to improve the conditions in their own countries . . .

Article 411 (later renumbered Article 26) of the Constitution is a broad recognition of the legal interest which all States, Members of the Organization, have in the maintenance of labor standards and in the welfare of workers. The Article provides:

> I. Any of the Members shall have the right to file a complaint with the International Labour Office if it is not satisfied that any other Member is securing the effective observance of any Convention which both have ratified in accordance with the foregoing articles.

Article 423 of the Constitution provides:

> I. Any question or dispute relating to the interpretation of this Part of the present Treaty or of any subsequent convention concluded by the Members in pursuance of the provisions of this Part of the present Treaty shall be referred for decision to the Permanent Court of International Justice. (See, in general, Jenks, *International Protection of Trade Union Freedom*, pp. 157–161.)

Acting on the basis of Article 26 (to use the numbering of the amended text) of the Constitution, the Republic of Ghana sent a communication to the Director-General of I.L.O. on 24 February, 1961, in which it stated:

> The Republic of Ghana is not satisfied that Portugal is securing the effective observance in her African territories of Mozambique, Angola and Guinea of Convention No. 105 (Abolition of Forced Labour Convention, 1957) which both Portugal and the Republic of Ghana have ratified.
>
> Accordingly, the Republic of Ghana requests that the Governing Body of the I.L.O. take appropriate steps, for example, by setting up a Commission of Inquiry to consider this complaint and to report thereon.

The Governing Body of the I.L.O. on 10 March, 1961, approved the report of its Officers in regard to the procedure that included the creation of a Commission of Inquriy. The judicial nature of the inquiry is indicated by the composition of the Commission: the Chairman was a Member of the Permanent Court of Arbitration, another Member was a former judge of the International Court of Justice and had previously been President of the High Court of Justice in his own country, and the third Member was the First President of the Supreme Court of another country. Further, the Commission in its report said:

> The Governing Body in appointing the Commission placed special emphasis on the judicial nature of the task entrusted to it, indicated its desire for "an objective evaluation" of the contentions submitted by "an impartial body" and required the members of the Commission before taking up their functions to make a solemn declaration in terms corresponding to those of the declaration made by Judges of the International Court of Justice.

The Commission also noted in its report that if its findings or recommendations were not accepted by both governments, either one of them might refer the case to the International Court of Justice under Article 29 of the Constitution of the I.L.O.

A similar Commission later examined the complaint of Portugal concerning the observance by the Government of Liberia of the Forced Labour Convention of 1930 (No. 29). The role of such Commissions in the administration of justice in labor problems is well stated in the report of the Commission, which was composed of an Argentine jurist who was a former judge of the International Court of Justice, a judge from Ceylon, and a Finnish professor with wide experience in international arbitrations:

> In these circumstances, the Commission cannot regard the complaint as calling for summary dismissal on the ground of its alleged political character. The Commission is not concerned with any political aspects which the matter may have; the task entrusted to it is that of examining judicially whether or not there has been or is a failure by Liberia to secure the effective observance of the provisions of the Forced Labour Convention, 1930 (No. 29), ratified by Liberia on 1 May 1931. In taking this view the Commission has been guided by a series of decisions of the International

> Court of Justice in cases in which it was contended before the Court that it should decline to give an advisory opinion by reason of the political nature of the questions on which its opinion was requested, and notably by the decisions of the Court in the *Conditions of Admission of a State to Membership of the United Nations (Article 4 of the Charter)* case and the *Certain Expenses of the United Nations* case. As was said by the Court in the *Conditions of Admission* case, the Commission "is not concerned with the motives which may have inspired this request"; it is no part of its function either to endorse or to impugn them; while the question referred to the Commission may be, to use the language of the Court in the *Expenses* case, "intertwined with political questions", the task of the Commission is to examine judicially without regard to such considerations, whether or not the obligations of the Constitution and the Convention are being carried out. (International Labour Organisation, *Official Bulletin*, Vol. XLVI, No. 2, Supplement II, April 1963, at p. 155.)

More recently the International Labour Organisation has used another technique for investigation, that of study and report but with no attempt to pass judgment; the question was the situation of trade unions in Spain. The Spanish Government invited and aided the inquiry.

* * *

We have noted that there is an established legal doctrine concerning a State's responsibility for denial of justice to the citizens or corporations of another State. The same term is not used when a State complains that another State has violated the rights of the State itself—for example, by invading its territory—although this is considered a violation of international law. The failure of the United Nations Security Council to administer justice in such situations has been revealed day after day in the Middle East. The organs of the United Nations, as already noted, administer rebukes but not justice. Nevertheless, the Secretary-General through his representatives in that troubled area, in Kashmir and elsewhere, has exercised the role of an administrator of justice. Truce supervision is an aspect of that function. In Cyprus, as once in the Congo and in the Middle East, the "blue berets" of United Nations forces are symbols of justice administered.

One should recognize that justice is administered even where some important body of opinion disagrees with the solution at which a decision-making body has arrived. One may go back to the outraged outcry against the Court's decision in the *cause célèbre* of Sacco and Vanzetti. Even if one maintains that a particular decision of a court is unjust, according to a chosen criterion or predilection, this too is an aspect of the administration of justice, paradoxical as the statement may be. Rarely are both parties to a contentious case in a national or an international tribunal ready to agree that the decision is correct, but they may agree that the Court has been just in that it has impartially addressed its learning and its judicial industry to the controversy. In the same way, a compromise solution may be just, although neither party is satisfied.

Given the situation in which States must consent to the Court's jurisdiction before it can pass judgment, that is administer justice, one can sympathize with the reluctance of a State that feels its most vital interests are at stake. One has less sympathy for governments that reiterate their devotion to the international rule of law and the functioning of the International Court of Justice but cannot bring themselves to submit even minor cases to the Court as concrete evidence of that devotion, for fear the judgment will be adverse, although the resulting loss would be scarcely consequential.

What must be abandoned is the idea that it is an unfriendly act to bring to the bar of justice a friendly State with which there is an unresolved controversy. Some 60 years ago, it was considered a great step forward when, at the Second Hague Peace Conference, the States of the world agreed that an offer of mediation or good offices could never be resented as an unfriendly act. What more tangible sign of friendly relations than the mutual agreement to submit a dispute to the International Court of Justice, just as England and France, Belgium and Holland, Honduras and Nicaragua, Cambodia and Thailand have submitted to the Court's judicial fixing of their respective territorial claims? Just after the American Civil War, the United States and Great Britain set a great example in submitting to an international tribunal the so-called *Alabama* claims, which arose from the depredations of the Confederate cruiser that Britain allowed, in violation of its duties as a neutral, to be outfitted in its ports. So the same countries submitted to international adjudication the North Atlantic Coast Fisheries dispute, the Bering Sea Seal Fishery dispute, the Alaskan Boundary dispute. Under a 1910 treaty that followed earlier precedents, England and the United States set up a special international tribunal that heard numerous small claims of each against the other. Why is this practice not repeated? Are there no matters involving points of law on which the two countries in their mutual relations are now in disagreement? I find it hard to accept a totally negative answer. Should they not continue to offer leadership in the cause of the international administration of justice?

As a lawyer and former judge, I hasten to admit the limitations of the law. Röling (*International Law in an Expanded World* (1960) p. 94) puts the case well, although his dichotomy between law and justice is too sharp:

> In the present-day community of international law the "old world" emphasizes the positive law of nations—the instrument and symbol of its former supremacy; whereas the "new world" appeals to justice. Here, too, the Charter already gives expression to the new relationships. In general, justice is mentioned before positive international law (as in the Preamble.) In the important Article 1, Section 1, the solution of differences "in conformity with the principles of justice and international law" is stated to be the means by which the peace aims of the United Nations can be performed. The fact that "justice" is mentioned before "international law" here, means that adherence to positive international law is not compulsory in the striving after "adjustment."

The Charter bars the United Nations from intruding in domestic questions. Because no State can live unto itself alone in this modern world, many matters once considered "domestic" have, under the impact of technology, become of

international concern. Given the feebleness of the international machinery for the administration of justice, that concern may be manifested only by sympathy or by the gnashing of teeth; if only the United Nations itself had teeth!

Organs for the administration of justice are not gadgets to be invented by some clever technician. The difficulty lies with what Loren Eiseley calls "the fossil ape encrusted in our hearts."

LEGAL BASES FOR SECURING THE INTEGRITY OF THE EARTH-SPACE ENVIRONMENT

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Like Wordsworth's world, the facts about man's contemporary damage—and threats of even more perilous future damage—to his environment are almost too much with us. They scream in horrifying detail, not merely from the face of nature but from every medium of communication. In urgent summary, United Nations Secretary-General U Thant finds a mounting "crisis of worldwide proportions," with portents long apparent "in the explosive growth of human populations, in the poor integration of powerful and efficient technology with environmental requirements, in the deterioration of agricultural lands, in the unplanned extension of urban areas, in the decrease of available space and the growing danger of extinction of many forms of plant and animal life." [a] When one recalls also the accelerating damage to the oceans, it is not surprising that the Secretary-General should conclude that "if current trends continue, the future of life on earth could be endangered." [b]

Similarly, although our need for new and more precise information is enormous, our knowledge about the causes of all this damage, both actual and potential, appears to be increasing. Ecologists have come to emphasize what community planners have long known, that there is a maze of complex and intimate interdependences—an "indivisible web" of interrelationships—both among the features of the natural environment such as air, climate, topography, soil, geologic structure, minerals, water resources and access to waters, natural vegetation, and animal life and between such features and the institutions and practices by which man seeks to satisfy all his many social and psychological needs and demands, as well as basic bodily needs for nutrition, procreation, shelter, safety, movement, and so on.[c] These interdependences extend through many different interpenetrating communities, from local or minute to global or earth-space in range. It is in the violation of these interdependences—in the transgression of many different resources, technological, and utilization unities—that the root causes of damage to the environment are beginning to be revealed.

There would appear, further, to be a growing consensus among the peoples of the world about the appropriate overriding goals for general community action in lessening the near-disastrous damage with which we all threaten each other. The emerging aspiration of mankind is not so much for some simple conservation of resources or environment in a pristine, untouched state of nature as for an appropriately conserving, economic, and constructive employment of resources in the greater production and wider distribution of all basic human dignity values. In many contemporary conceptions, the resources of the globe are increasingly regarded as the common patrimony of the whole of mankind; practices in the exploitation of resources are being assayed in terms of their aggregate consequences for all who are affected, and costs-benefits analyses are being extended beyond mere quantitative calculations about wealth to qualitative assessment of impacts on the shaping and sharing of other representative values, such as power, enlightenment, respect, health, skill, rectitude,

and affection. This would appear to be the empirical reference of the somewhat amorphous demand, so often expressed in popular discussion, that resources and environment be protected and maintained for improving "the quality of life."

The invention of effective remedial measures—of appropriate technical solutions—for the better securing of these overriding goals of the general community would not, once again, appear to be beyond the reach of man's creativity. The damage is not yet universal or irreversible, and the same science and technology that contribute to the difficulties also immensely enhance the potentialities for alleviation. In our national communities, many of us have had a rich and enlightening experience in the allocation, planning, development, and control of resource use for multiple-value goals. If, however, appropriate account is to be taken of the interdependences that pervade both the natural environment and man's practices in the shaping and sharing of values, any remedial measures or technical solutions that would be effective through time and for consequential geographic areas must eventually extend to planning, development, and controls that are comprehensive, integrated, and rational for the whole global community, as well as for its many internal communities: no national community today can be an island in a universe of interdetermination.[d] In addition, it is obvious that if such comprehensive planning, development, and controls are to be achieved and made to serve the overriding goals of both maintaining a secure environmental base and promoting and augmenting human dignity values, many delicate and continuing adjustments will be required in the management of processes of authority and effective power at all levels of government, from local through national and regional to global.

For specialists in law, the important question posed, in this gradual identification of the problem, is: What are the creative potentials in the management of processes of authoritative decision for contributing to the clarification and implementation of the common interests of the peoples of the world in protecting, and securing the more constructive enjoyment of, their shared environmental base?

It is the thesis of this paper that these potentials are sufficiently high to afford ground, not for complacency, but for at least a modest optimism.

It is not, of course, our suggestion that existing processes of authoritative decision, or the governmental structures in which such processes occur, are adequate to secure mankind's basic goals in relation to its environment. What we would suggest is rather that we do today have sufficient general knowledge about, and skills in, the management of processes of authoritative decision and sufficient assets in our inherited, and rapidly improving, global constitutive process and presently established public order policies about the control of resources greatly to encourage the expectation that, if the perspectives of the effective élites of the world can be appropriately shaped, much more rational and economic processes of authoritative decision can quickly be constituted and managed for better securing basic goals.

The full documentation of this thesis would require performance of a sequence of intellectual tasks, including:

(1) the detailed specification, in their context of causes and consequences, of the more important problems arising from man's contemporary interaction with and exploitation of his environment;

(2) the clarification in detail, from the perspective of an observer identifying with the whole of mankind, of basic general community policies in relation to each of these particular problems;

(3) a survey of past experience, of prior trends in decision, at all levels of government, from local to global, in terms of approximation to clarified policies;

(4) an investigation of the factors that have affected past decisions on particular problems;

(5) the projection of probable future decisions and conditioning factors in relation to particular problems; and

(6) the recommendation of new alternatives in constitutive process and public order prescriptions for the better securing of clarified policies.

The most that can be attempted here is an impressionistic indication of the basic legal assets at our disposal for undertaking inquiry and, ultimately, action. These assets include, as suggested above, our general knowledge about, and skills in, the management of legal processes, the existing global constitutive processes of authoritative decision, and the presently established public order policies relating to the allocation, planning, development, and exploitation of resources. We will glance briefly at each of these different types of assets and note certain possible directions toward improvement.

Perspectives about, and Skills in, Law

The increasingly predominant theory ("jurisprudence" or "philosophy") about law today is explicitly sociological or policy-oriented in emphasis. In this conception, law is not some frozen set of pre-existing rules or arrangements that inhibits constructive action about environmental and other problems but, rather, a dynamic and continuous process of authoritative decision through which the members of a community clarify and implement their common interests. Rejecting the mysticism of natural law emphases, the fatalism of historical emphases, and the arid technicality of analytical or positivistic emphases, this contemporary sociological or policy-oriented conception seeks to facilitate the bringing to bear upon community problems, within the constitutive processes through which common interests are clarified and implemented, all the findings and techniques for modern social and physical science. The major features of this emerging emphasis may be briefly indicated.[e]

Observational Standpoint

In contemporary inquiry about law we have learned to distinguish the standpoint of the scholarly observer, primarily concerned with enlightenment and skill, from that of the decision maker, primarily concerned with power—that is, for participation in the making of effective decision. The scholar, detaching himself and his procedures from the events (including the purposes and procedures of the participants in processes of decision) that he has under observation, seeks to create and employ a *functional* theory both to establish a comprehensive and relevant focus of attention and to facilitate performance of certain indispensable intellectual tasks in reference to the flow of authoritative decision and of the *conventional* theories employed to explain and justify

such decision. The identifications the scholar seeks are not merely with some single parochial community but, rather, with the whole of man's many different—often concentric, and always interpenetrating—communities and the enlightenment he seeks is that relevant to clarifying and implementing the common interests of all.

Focus of Inquiry

Eschewing definitional exercises, contemporary jurisprudence aspires to a focus of inquiry that is both comprehensive and selective, effectively relating authoritative decision to the larger social and community processes by which it is affected and which it in turn affects. This comprehensiveness and selectivity are sought by certain subordinate, interrelated emphases.

(1) A balanced emphasis upon perspectives and operations: The central focus is squarely on *decision*, as effective choice, composed of both perspectives and operations. Exaggerated emphasis is avoided either on technical rules of law, too often assumed to be an accurate expression of community perspectives, or on bare, behavioristic operations, the choices in fact made and enforced by threats of severe deprivations or promises of extreme indulgences. In balanced inquiry about patterns in both perspectives and operations, the manifest content of conventional rules of law is pierced for examination of the choices in fact made, while perspectives are still subjected to systematic and realistic study as among the factors importantly affecting decision.

(2) Clarity in conception of both authority and control: Authoritative decision is distinguished from naked power, and law is regarded not merely as decision, but as *authoritative* decision, in which elements of both authority and control are combined.

Authority is found, not in theological or metaphysical or allegedly autonomous abstractions, but rather—in a conception at least as old as the pre-Socratic Greeks—in the empirical perspectives of community members about who is to make what decisions, in respect to whom, in accordance with what criteria, and by what procedures.

By control is meant participation in effective choices, in choices that are in significant degree put into practice; control, in this sense, may obviously be based on any of the wide range of community values.

(3) Comprehensiveness in conception of processes of authoritative decision: Relevant inquiry extends beyond occasional, isolated choices, to the whole, continuous, ever-changing *process* of decision by which a community shapes and shares its values. In any community, the process of authoritative and controlling decision, which is the appropriate reference of "law," is seen to be composed of two different kinds of decisions: the "constitutive" decisions that establish and maintain the most comprehensive process of authoritative and controlling decision; and the "public order" decisions that emerge from the process so established for the regulation of all other community value processes.

The constitutive process of a community comprises the decisions that characterize and identify the appropriate decision makers, specify and clarify basic community policies (which may be demanded in varying degrees of intensity), establish necessary structures of authority, allocate bases of power for sanctioning purposes, authorize procedures for making the different kinds of decisions, and secure the performance of all the different kinds of decision functions (intelligence, promotion, prescription, invoking, applying, terminating, and appraising) necessary to making and administering general community policy.

The public order decisions of a community are those that shape and maintain the protected features of its different value processes. These include the decisions by which resources are allocated, planned, developed, and exploited; by which populations are protected, regulated, and controlled; by which health is fostered or neglected; by which human rights are protected or deprived; by which enlightenment is encouraged or retarded; and so on.

(4) Explicit relation of law to social process: Since authoritative decision is a response to events in social process, is affected by such events, and, in turn, has effects on the future distribution of values, a comprehensive set of value-institutional categories—making detailed, empirical reference to interrelations among people—is employed to locate authoritative decisions in the larger social processes that envelop them. By such categorizations the different types of claims people make to authoritative decision and the varying responses of established decision makers may be compared through time and across territorial boundaries in study of the factors that affect decision and of the public order consequences of decision.

(5) Location of law in its larger community context: In contemporary conception it is recognized that mankind today interacts on a global and even earth-space scale, not merely in the sense of a universal science and technology, but of an interdetermination with respect to all values. One component of this larger, if still primitive community, is seen to be a process of *effective* power, in that decisions are in fact taken and enforced, by severe deprivations or high indulgences, which are inclusive in their effects. Among these effective decisions it is observed that, although many continue to be made by naked power or sheer calculations of expediency, some are taken from perspectives of authority and achieve enough control to be of high consequence. Like the all-inclusive transnational social processes, this latter transnational process of authoritative decision—sometimes ill-described as "international law"—is seen to be maintained at many different community levels and in many different interpenetrating patterns of authority and control, in affecting and being affected by the value processes of all the component communities of the larger earth-space community. A global public order is, thus, seen to affect the internal public order of all particular communities, and the public order of each particular community to affect, in turn, the global public order.

Relevant Intellectual Tasks

In lieu of traditional exercises in derivational logic and concern for limited conceptions of "science," contemporary theory about law emphasizes the deliberate, systematic, and differentiated performance of a comprehensive set of intellectual tasks, each of which is relevant to problem solving about the interrelations of law and social process. The economic and effective performance of any one task requires its relation, configuratively, to the formulations and findings achieved by each of the other tasks.[1]

(1) Clarification of community policies: The most relevant clarification, avoiding circular derivations, deliberately seeks the detailed specification of

postulated goals, whatever the level of abstraction in their initial formulation, in terms that make clear empirical reference to preferred events in social process. The findings and techniques of each of the other intellectual tasks are employed to estimate the aggregate consequences of alternatives in choice and to relate such consequences to common interest.

(2) Description of past trends in decision: In supplement to conventional summaries of complementary rules and concepts, the description of past trends in decision is related to specific, detailed types of claims to authority, and trends are appraised in terms of degrees of approximation to clarified policies for constitutive process and public order. For the more effective comparison of decisions and their consequences through time and across community boundaries, the events that precipitate claims to authoritative decision, the decisions actually taken, and both the immediate and longer-term consequences of decision for the claimants and others are all categorized "factually," in terms of value-institutional references to social process.

(3) Analysis of factors affecting decision: In performance of the scientific task, hypotheses are inspired by the "maximization postulate" that responses are, within the limits of capabilities, a function of net value expectation, and emphasis in inquiry is placed on both predispositional and environmental variables. The techniques and findings of modern science are brought to bear in appraising the significance of multiple factors from culture, class, interest, personality, and previous exposure to crisis.

(4) Projection of future trends in decision: Expectations about the future are made as conscious, explicit, comprehensive, and realistic as possible. Developmental constructs embodying alternative formulations of the future are deliberately formulated and tested in the light of all available information. The simple linear or chronological extrapolations of conventional legal rules are subjected to the discipline of knowledge about conditioning factors and past changes in the composition of trends.

(5) Invention and evaluation of policy alternatives: All the other intellectual tasks are synthesized and brought to bear on the deliberate invention and assessment of new alternatives in policy, institutional structures, and procedures. Every phase of decision process, whether of constitutive process or relating to public order, and every facet of the conditioning context, are examined for opportunities in innovation that may influence decision toward greater conformity with clarified goals. Assessment of particular alternatives is made in terms of gains and losses with respect to all values and disciplined by the knowledge acquired of trends, conditioning factors, and future probabilities.

Explicit Postulation of Basic Community Goals

In recognition that policy choices are ineradicable components of any process of authoritative decision, a policy-oriented jurisprudence recommends that scholars explicitly postulate, and commit themselves to, a comprehensive set of goal values for the guidance of inquiry and decision. Postulation and clarification, rather than derivation from the premises of some particular faith, are recommended both for economy and for increasing the number of potential co-workers. The basic goal values postulated for preferred world public order cannot, of course, be expressive only of the exclusive, parochial demands of some particular segment of mankind, but when overriding goals are shared, particular values can admit of a very great diversity or functional equivalence in the institutional practices by which they are sought and secured.

The World Constitutive Process of Authoritative Decision

It is sometimes lamented that, while environmental problems are global in their reach, the processes of law are not. This is a profound misconception. The contemporary world arena does exhibit a constitutive process that, though it has not yet achieved that high stability in expectations about authority and degree of effective control over constituent members that characterize the internal processes of some mature national communities, still affords, in at least rudimentary form, all the basic features essential to the effective making and application of law on a global scale. In recent decades, this emerging transnational constitutive process of authoritative decision has been expanding and improving itself at an accelerating rate, and it would not appear that vast, and possibly grandiose, structural alterations are any more necessary for coping with environmental than for other problems. Conversely, environmental problems would indeed appear so global in their reach and so immense in proportion that a whole global process for the continuous clarification and implementation of common interest, and not merely some new specialized organization or cluster of organizations, is required for their management and amelioration. The basic features of existing constitutive process, as they suggest potentiality for the more effective management of environmental problems, may be briefly indicated.[5]

Participation

In recent decades, participation in world constitutive process, as in the embracing process of effective power, has been tremendously democratized—with not merely nation-states but also international governmental organizations, political parties, pressure groups, private associations, and individual human beings playing important roles. With this increase in the range of effective participants has come also a rapid proliferation in the number of territorial and functional entities demanding and being given voice. Similarly, a multiplying host of private associations, operating within the larger constitutive process, are increasingly international in membership, goals, and arenas of activity. Groups and individuals especially concerned with environmental problems have abundant opportunity to participate in all aspects of making and applying law.

Perspectives

The perspectives of the effective élites of the world, on which processes of authoritative and controlling decision must depend, would appear to exhibit both an increasing stability and a turgid, but perceptible, movement toward the demands, identifications, and expectations appropriate to public order of human dignity.

The demands of peoples upon constitutive process increasingly emphasize

the necessity for protecting common interests, with the rejection of all claims of special interest against community. The provisions of the United Nations Charter, including Art. 2(4) and various ancillary articles, have made a tremendous contribution to the clarification, if not consistent implementation, of the common interest in minimum order (the minimization of coercion and the protection of reasonable expectations created by agreement and customary behavior). Other provisions of the Charter, the Universal Declaration of Human Rights, and the multitude of more specialized covenants about human rights have, similarly, done much to clarify the details of common interest in optimum order (the greater production and wider sharing of all values).

The rich experience of mankind—as expressed in customary development, United Nations resolutions, and specialized agreements—in clarifying and implementing common interests in the enjoyment of such great sharable resources as the oceans, airspace over the oceans, international rivers, polar regions, and outer space could fortify efforts to achieve a comparable, more generalized clarification for environmental problems, which embrace all resources, including even the land masses.

Increasing interactions on an earth-space scale would appear to be fostering expanding identifications among all peoples with the whole of mankind, as well as occasional, parochial, defensive reactions. Authoritative decision makers increasingly achieve an appropriate balance between inclusive and exclusive identifications.

The ineluctable spread of a civilization of science and technology carries with it, as one important component, as increasingly common map of reality and expectation about social process and environment for all men. With respect to environment, if not social process, expectations could become more contextual, realistic, and rational, and all men might come to see that they share a common fate.

Arenas

The structures of authority and other situations in which the participants in world constitutive process interact have exhibited in recent years both an enormous expansion and a modest movement toward organized, inclusive form. A principal contribution of the United Nations and of the great host of specialized agencies and regional organizations has been in the supply of a new abundance of diplomatic, parliamentary, mixed diplomatic and parliamentary, adjudicative, and executive arenas in which the other effective participants in world power process can interact. A comparable increase has occurred in the patterns of interaction established by burgeoning private, nongovernmental associations primarily dedicated to values other than power. In consequence, the interactions of the decision makers whose choices in sum create global policy have become more timely and continuous—i.e., less episodic and more alert and responsive to crisis.

Similarly, though some official arenas remain closed to some effective participants, there has been a general trend toward openness in arenas and a parallel movement toward making appearance compulsory for participants whose choices in fact affect community policy. Both openness and compulsoriness are promoted by increasing interdependences in effective power.

Bases of Power

While many of the more important bases for influencing decision remain under the relatively exclusive control of nation-states, there appears to be a

modest trend toward allocating to representatives of the inclusive community the authority and other assets required for the better securing of both minimum and optimum order.

With respect to authority, one encouraging development is the attenuation of the concept of "domestic jurisdiction" (the exclusive competence of states) and the expansion of that of "international concern" (the inclusive competence of the general community). The distinction is now made in terms of the relative impact of activities on exclusive and inclusive interests, and the competence of the general community is being extended, through varying decision functions, to all matters of transnational impact. This extension of the competence of the general community is, of course, of particular relevance for the regulation of environmental modifications and practices in resource exploitation whose transnational impacts are obvious.

Similarly, though the myth abides that very little authority is being conferred on specific international organizations, the facts about peoples' expectations appear to be quite different. The actual authority of the United Nations, the specialized agencies, and the regional organizations would appear to be enormous, in the sense of the support they receive from the demands, identifications, and expectations of the peoples of the world.

The more traditional principles of jurisdiction, which allocate an exclusive competence for self-help among nation-states, are also coming to be interpreted in terms of the relative impact of activities on different exclusive interests. Under contemporary interpretations, states are authorized to protect themselves, by necessary and proportionate measures, against activities from the outside that substantially affect their internal community processes. This competence, too, would appear to be of direct relevance to environmental problems.

In the allocation of the effective control necessary to sustain authority, there is, similarly, a slow movement toward greater inclusivity in fact. It may be noted that an allocation of control designed to secure an appropriate balance between inclusive and exclusive decision making need not imply the complete centralization of control; a pluralistic distribution of values among the peoples of the world may better maintain an appropriate balance.

The worldwide spread of enlightenment and skills, facilitating perception of interdependences and common interests, and modern institutions of instantaneous communication have, of course, concentrated immense assets in the hands of inclusive decision makers. The expanding identities and loyalties of peoples, as transnational interactions accelerate, and the increasing internationalization of standards of rectitude and of respect for human rights add to these assets. More tangible assets may, perhaps, yet be found in the great sharable resources—such as the oceans, the airspace over the oceans, the polar areas, and outer space—which, despite recent inroads on behalf of special interests, are still largely under inclusive competence and control.

Strategies

Improvements in communication, expanding scientific knowledge and skills in observation, and accumulating experience in large-scale administration have all combined in recent years to facilitate a gradual rationalization of the procedures by which participants manage base values in performance of the different policy functions necessary to the making and application of law. The

exploration of potential facts and potential community policies is being made more dependable, contextual, selective, and creative; the final characterization of facts and policies in prescriptive or applicative decision is being made more deliberate, rational, and nonprovocative; and the communication of the shared subjectivities indispensable to legal process is being made more effective.

(1) The diplomatic instrument: With the multiplication of new, more stable, and more continuous arenas, the old diplomacy of occasional official or élite communication is being transformed into a kind of parliamentary representation and activity, as in the United Nations. Important new multilateral conventions have been formulated and accepted for guiding and assisting diplomatic interactions and the making and performance of agreements. New procedures are constantly being devised and tested for executive and adjudicative arenas.

(2) The ideological instrument: The potentialities of instanteous communication about the globe, to mass audiences beyond élite groups, promise both greatly to increase participation in global constitutive process and profoundly to affect performance of many policy functions, such as—especially—promotion, prescription, and application.

(3) The economic instrument: Though direct control over resources and the management of wealth processes are still largely reserved to the exclusive competence of nation-states, the organized general community is acquiring an increasing experience in the promotion of economic development and in the management of credit and monetary policies. Some expansion of this role could greatly enhance the potential of the economic instrument in promoting desired world public order.

(4) The military instrument: Despite the failure of the original plan to establish within the United Nations a permanent military force for the maintenance of minimum order, the United Nations has had some minor successes in different parts of the world in assembling and employing small forces. Somewhat greater cooperation has been achieved at regional levels. Perhaps these successes could again stimulate plans for a more ambitious inclusive employment of the military instrument in support of general community policies.

The promise of the integrated employment by the organized general community of all four instruments of policy, in the management of all relevant base values, for the improvement of sanctioning process in the establishment and maintenance of desired world public order remains, of course, largely for future exploration. In the meantime, the more important sanction for transnational law, as for most national law, resides in the perception by community members of their interdependences and common interests and in their expectations about reciprocal, unilateral indulgences and retaliations in relation to such interdependences and interests.

Outcomes

In consequence of the gradual modification and improvement in all these varying phases of constitutive process there has been a parallel improvement in the culminating outcomes of the process in the different types of decisions taken. The relevant decisions appear to be becoming more comprehensive, in the sense of embracing all necessary policy functions; more inclusive, in the sense of extension toward participants and interactions affecting common interests; more rational, in the sense of conformity to the basic public order demands and expectations of the peoples of the world; and more integrative, in the sense of molding the potentially divisive claims of peoples into the perception and fact of common interest.

(1) Intelligence: The recent proliferation of international governmental organizations and the enhanced participation in constitutive process of political parties, pressure groups, and private associations have immensely increased facilities for the gathering, processing, and dissemination on a global scale of the intelligence necessary to rational decision. The emerging technology of observation and communication by outer-space instrumentalities offers still further augmented potentialities. The massive and complex intelligence required for effective management of environmental and resource problems appears to be well within reach but will require cooperation on a larger scale than heretofore throughout the entire constitutive process.

(2) Promotion: The increasing democratization of participation in world processes of effective power, the availability and openness of the new structures of authority, and the contemporary instrumentalities for communication have, similarly, brought a new comprehensiveness and intensity to the active advocacy of policy alternatives before authoritative decision makers. The ease with which demands can be formulated and propagated, and support mobilized, for the enactment and application of new authoritative prescriptions is already being demonstrated on a global scale in relation to environmental problems.

(3) Prescription: Historically, the making of transnational law has gone forward by way of articulated multilateral agreement and of unarticulated, habitual, cooperative behavior, from which expectations about authority and control are derived. The practices of the United Nations have both given a tremendous boost to these traditional modes of lawmaking and added a new dimension that reflects a closer approximation to parliamentary enactment. The activities of the International Law Commission and of the General Assembly, through its committees, have greatly rationalized prescription by multilateral agreement, as witness the important new conventions about the oceans and outer space. The opportunities afforded in the General Assembly for the representatives of many different communities to state their conceptions of prevailing law and to articulate these conceptions in formal resolutions have, further, greatly eased the historic burden of identifying customary law and clarifying its content. It is this latter modality of General Assembly resolution, greatly foreshortening the time necessary for establishing customary law and affording an economic mode for articulating consensus about common interest, that increasingly bears the hallmarks of parliamentary enactment. Clearly, if inherited prescriptions about the protection of the environment are inadequate, the prescribing process offers few impediments to their being made adequate.

(4) Invocation: Though some arenas remain closed to some participants, as the International Court of Justice at present is to individuals and nonstate entities, most participants today either have many arenas open to them or else can easily find a surrogate or champion who does have access, for stimulating the application of community prescriptions. The community member who would complain about the violation of prescriptions for environmental protection has abundant opportunities for a hearing.

(5) Application: Historically, the great bulk of the applications designed

to put general community prescriptions into controlling effect in particular instances have been made in interactions between foreign office and foreign office or in national courts. The fact that the same participants have had to be, alternatively, both claimants and appliers has been not so much a source of bias as a guarantee of aggregate decision in terms of common interest. In recent decades there has been a modest movement toward third-party decision—through international courts, arbitral commissions, and various structures of authority within international organizations—and toward compulsory attendance by participants whose activities are alleged to transgress community prescriptions. Important recent illustrations of this trend appear in conventions relating to the conservation of fisheries and to the law of treaties. If compulsory jurisdiction becomes acceptable in relation to environmental problems, there is no want of models for making it effective.

(6) Termination: The same developments in United Nations practice that have brought a new economy and flexibility to performance of the prescribing function have resulted in comparable improvements in procedures for putting an end to outmoded prescriptions and arrangements, with appropriate measures for the compensation of those who suffer disproportionate loss. In lieu of traditional assertions of unilateral naked power or reliance on a mutual consensus difficult to achieve, parties contending about termination today more frequently resort to organized authoritative arenas, such as in the United Nations or *ad hoc* conferences, and to collective determinations.

(7) Appraisal: The same factors that contribute to improved performance of the more general intelligence function serve equally to facilitate specialized inquiry about the adequacy of past decision processes to secure postulated goals. The expanding contemporary world focus of attention could encourage all participants, official and nonofficial, to undertake more systematic and intensive appraisal of the success of past process in coping with environmental problems.

An examination of the internal constitutive processes of the different particular territorial communities contained within the larger global process would of course reveal that most of these communities possess much more mature and fully developed processes—amply endowed with supervisory, regulatory, entrepreneurial and corrective competences—for making and applying the law necessary to the more effective management of environmental problems within their exclusive territorial boundaries.[h]

Inherited Public Order in Relation to Resources

Our inherited presciptions about the allocation and exploitation of resources, comprising in sum our environment, are not as archaic, irrelevant, and inadequate as is sometimes suggested. The exigencies inherent in the cooperative, interdependent exploitation of the world's resources have imposed severe restraints on the assertion of special interests, even in relation to the land masses, and have encouraged the mutual recognition and reciprocal protection of common interests, both inclusive and exclusive, especially in relation to sharable resources. The general community, acting through the constitutive process described above, already allocates resources between inclusive and exclusive uses in a way designed to maximize inclusive competence, seeks to regulate and limit the injurious employment of resources by communities in

relation to each other, makes abundant provision for facilitating the productive and harmonious employment of resources, exhibits the beginnings of an appropriate network of planning and development institutions, and even aspires, through an increasing concern for human rights, to achieve a more rational relation of peoples to resources. The potentialities afforded by our inherited prescriptions for assisting movement toward improved environmental protection may be economically indicated in relation to certain basic, perennial problems.

(1) The allocation of resources: The principal achievement of past constitutive process in relation to resources has been in establishing that the great sharable resources of the globe—that is, those admitting of a high degree of shared use by reasonable, mutual accommodation, such as the oceans, the airspace over the oceans, international rivers, the void of outer space, and the celestial bodies—remain subject to relatively inclusive competence, open for inclusive use and not subject to exclusive appropriation by particular states.[i] This outcome, though increasingly threatened today by accumulating demands in terms of special interest, is fortified by the clear experience of mankind that it is inclusive competence and use that most often promote the greatest production and widest distribution of goods and services for the benefit of all. Only with respect to the land masses and closely proximate waters and airspace, which admit of the least degree of shared use, have states reciprocally honored each other's claims to comprehensive, continuing, and exclusive competence, and with the contemporary accelerating interdependences in the use of land masses, even this exclusive competence is becoming attenuated and being made a matter of degree.

Similarly, with respect to those resources that it has permitted to be subjected to exclusive appropriation, the general community has imposed quite severe conditions and limitations on such appropriation, including a genuine "occupation," in the sense of a comprehensive and continuous process of enjoyment and utilization, made known to all the world; limitations on the quantity of the resource subject to appropriation; and requirements for development within a reasonable time.

From these perspectives of authority, the general community clearly retains inclusive competence over many of the resources importantly affecting the quality of the environment, it could preclude the exclusive appropriation by states of any new resources made available by advancing science and technology for control of climate and environment, and it could condition the continuing control even of resources subject to exclusive appropriation to conformity with the dictates of common interest in the maintenance of a necessarily shared environment.

(2) The regulation of injurious employment in use: The general community, through its present constitutive process, seeks to minimize the losses caused both by major, deliberate attacks by states on each other's territorial integrity and by the less comprehensive, often unintended deprivations that inevitably attend transnational interaction.

The protection that the general community establishes against major, intended deprivations that threaten territorial integrity and independence today derives principally from the United Nations Charter and the ancillary procedures established thereunder. The basic prescription is that of Article 2, paragraph 4, which provides:

> All Members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any other manner inconsistent with the Purpose of the United Nations.

It would appear the common expectation of most of mankind that this policy of minimum order, indispensable to law in any community, applies not merely to activities on earth and to traditional exercises with the military instrument, but also to man's activities anywhere, as in outer space, and to any new techniques of coercion and deprivation made possible by manipulation of environmental variables.[j]

The protection established by contemporary constitutive process against less comprehensive, relatively nondeliberate, more ordinary acts of deprivation builds largely on customary international law, as occasionally reinforced by explicit agreement. A continuous flow of authoritative community decisions and of unilateral acknowledgements for many decades appears to be establishing that states regard themselves as reciprocally responsible for such deprivations, even to a degree approaching absolute liability. Perhaps the most famous and influential case in this line of decision is the *Trail Smelter Arbitration*[k] between the United States and Canada. In this arbitration, the tribunal found Canada responsible to the United States for damage caused by sulfuric fumes emitted by a smelter in British Columbia and affecting large areas in the state of Washington. Certain language from the opinion has been often quoted as a concise formulation of the international prescription:

> . . . under the principles of international law . . . no state has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence.
>
> . . . the Dominion of Canada is responsible in international law for the conduct of the Trail Smelter and, apart from the undertakings in the Convention, it is the duty of the Government of the Dominion of Canada to see to it that this conduct is in conformity with the obligation of the Dominion under international law as herein determined.
>
> . . . The Trail Smelter shall be required to refrain in the future from causing any damage through fumes in the State of Washington. To avoid such damage the operations of the Smelter shall be subject to a regime or measure of control as provided in the present decision. Should such damage occur, indemnity to the United States shall be fixed in such manner as the governments acting under the convention may agree upon.

The same authoritative policy that infuses this decision could be documented in many other specific decisions and in a great variety of state and private practice. Among the more famous cases are the *Corfu Channel* decision in the International Court of Justice and the *Lake Lanoux Arbitration*.[l] The most relevant practice, exhibiting expectations about responsibility, would include the recognition as lawful of "contiguous zones"—beyond the territorial sea—that are reasonably designed to protect against external injury; the mutual tolerance of "self-defense" or "self-help" anywhere on the high seas that is necessary and proportionate for dealing with threatened deprivation; and the emerging, generally accepted customary regime with respect to international rivers, which establishes "reasonableness" as the touchstone for adjusting the equities in use among riparians who cannot avoid affecting each other. The easy acceptance in multilateral convention and otherwise of strict liability for space activities and nuclear damage reflects comparable expectations.[m] The contribution of private, nonofficial practice to authoritative expectation is dramatically demonstrated in the recent voluntary settlement of the *Torrey Canyon* case and in the establishment of a continuing private association to deal with comparable future disasters.

(3) Facilitating the productive and harmonious employment of resources: The best exemplification of the high potentials of inclusive competence for effecting the productive and harmonious exploitation of sharable resources is the historic international law of the sea, which for some centuries has served the function of clarifying and securing, by shared reciprocity and mutual restraint, the common interests of all peoples in the greatest possible production and widest possible distribution of values from the oceans.[n] The basic framework of this law—established in the more comprehensive world constitutive process by habitual, cooperative behavior—has been, in a largely decentralized and unorganized arena, a few simple customary prescriptions, applied with an extraordinary economy and effectiveness: that all peoples enjoy equal rights of access to the oceans and to the appropriation of resources, such as fish, with respect to which exclusive appropriation is permitted; that each state makes and applies law to its own national ships and that no state may assert its exclusive, unilateral competence over the ships of other states save for violations of international law; and that no state may question the competence of another state to confer its nationality on a ship. These few simple prescriptions have, of course, been supported by a whole host of ancillary, implementing rules, established both by custom and by multilateral agreement, for fixing rules of the road, securing safe navigation, repressing piracy, promoting conservation, restraining pollution, accommodating and integrating different interests, and so on. The evidence would seem clear that over the centuries, despite the difficulties of recent days, this regime of inclusive competence, with a minimum monopolization of either authority or use, has served the whole of mankind well in creating the greatest net gains both in the indivisible value of general security and the divisible values of wealth, enlightenment, well-being, and so on.

A comparable regime is in process of being extended, both by customary prescription and by explicit agreement, to the sharable resources of outer space and the celestial bodies but, unhappily, has as yet been only partially extended to airspace over the land masses.

Even with respect to the land masses, commonly regarded as admitting of the least degree of shared use, a regime of modestly inclusive competence may be observed to serve the interests of a world economy and society. The prescriptions most importantly comprising this regime are those popularly described as "private international law" and as relating to the "responsibility of states."[o] The first set of these prescriptions are principles of jurisdiction—the principles of territoriality, nationality, protection of interests, impact territoriality, passive personality, the "proper" law of "contracts" and "torts," and so forth—which confer a competence on states to protect their internal community processes and their nationals from injury, even that originating beyond their boundaries. The second set of principles constitute an international "bill of rights," antedating the contemporary prescriptions about human rights, which impose certain limits on the competences of states, with respect to events otherwise within their "jurisdiction," for the protection of aliens and their property. In recent decades this aspiration in customary prescrip-

tion toward a world economy and society has been significantly implemented by explicit agreements and new specialized organizations, as in the International Monetary Fund, the International Bank for Reconstruction and Development, and the General Agreement on Tariffs and Trade.

(4) The performance of planning and development functions: The inclusive performance of planning and development functions has received great impetus from the recent proliferation of international organization. The number of organizations—governmental and nongovernmental, specialized and nonspecialized, general and regional—engaging in such functions in relation to activities with a direct bearing on environmental control is so vast as to defy even listing.[p]

The most comprehensive and important inquiries and activities obviously stem from the United Nations and its affiliated enterprises, but regional organizations, such as the NATO, and private associations are beginning to play increasingly significant roles.

For some indication of the range and complexity of contemporary planning and development activities, we note in relation to each of certain major resources a few of the organizations engaging in such functions.[q]

Energy Resources:

The International Bank for Reconstruction and Development
The International Atomic Energy Agency
The World Meteorological Organization

Natural Environments:

UNESCO
The World Wildlife Fund

Animal Life:

The Food and Agriculture Organization
The International Whaling Commission

Vegetation and Soils:

FAO
UNESCO
International Society for Plant Geography and Ecology
Inter-American Institute of Agricultural Sciences

Water:

FAO
WHO
UNESCO
WMO
IAEA
IMCO
The International Association on Water Pollution Research
The Council of Europe

Air:

IAEA
IMCO
WHO
The Council of Europe
The International Association Against Noise

Minerals:

Various United Nations agencies
Many specialized private associations

Weather and Climate:

WMO, including World Weather Watch Program
International Civil Aviation Agency.

(5) The relation of peoples to resources: The most obvious inadequacy in inherited public order concerns the relation of people to resources. The access of peoples to communities (and hence to the resources exclusively appropriated by such communities) and movement between communities is made dependent largely on the "nationality" of individuals, and states are permitted to prescribe and apply highly restrictive policies in the granting and denying of nationality.[r] In a global arena in which expectations of violence are high, states recognize, and reciprocally honor, a common interest in the exclusive protection of their bases of power and take the most severe measures to make certain that their members remain available to themselves and their allies and do not undermine internal power structures. They impose, and acquiesce in, highly arbitrary restrictions on freedom of circulation and freedom to change memberships, and employ stringent negative sanctions to secure conforming conduct.

Some amelioration of historic attitudes has begun to appear in the contemporary human rights program, which projects prescriptions favoring freedom of movement between communities and freedom to change community memberships; in the increased honoring in the United Nations of the right of peoples to "self-determination" when based on appropriate conditions of security and economy in the shaping and sharing of values; and in the accelerating movement toward a more rational regional organization of the world arena and world society. The preferred policy, most compatible both with human rights and the productive employment of resources, appears to favor a high voluntarism in travel, affiliation, and participation. For the rational shaping and sharing of most values, the present boundary lines between nation-states are as outmoded as the comparable demarcations between provinces within nation-states.

Transnational efforts to control population growth raise even more difficult, and almost unprobed, issues of policy and legal technique.

Alternatives for Improvement

One of the premises with which we began our discussion was that changes in the environment, whether beneficial or injurious, are an inextricable component of the continuous process of social interaction by which resources are

employed in the shaping and sharing of values: injury to the environment may not be inevitable in such process, but the practices by which injury is inflicted are indistinguishable from the ordinary practices of production and distribution and are omnipresent. Another premise was that emerging general community goals in relation to protection of the environment extend, beyond the mere minimization of particular losses, to the maximization of gains in the production and distribution of all human dignity values.

From these perspectives it is apparent that the demanded quality of environment is, and must in a world of ever-increasing interdependences continue to be, affected by every feature both of global constitutive process and of the internal constitutive processes of its lesser constituent communities. It is sometimes proposed, as by George Kennan,[a] that there immediately be created a new specialized international governmental agency charged with the performance of intelligence, promotion, invocation, and appraisal functions with respect to environmental problems. Conceivably, such an organization—if accorded the necessary bases in authority, manpower, and finances—could do much to improve the functioning of global constitutive process in relation to its purposes. Clearly, however, it would not be enough: there would remain the functions of prescribing new and more appropriate standards as general community policies and of applying these policies in particular instances to put them into controlling practice; the new agency could not be given authority even in relation to the intelligence, promotion, invoking, and appraising functions over all the activities in production and distribution that affect environment without constituting in effect a comprehensive world government in lieu of present constitutive process; and the internal constitutive processes of the different territorial communities making up the world arena would still require renovation.

The observer who would be effective in recommendation about environmental protection need not decry, and may on the contrary rationally participate in, efforts to create new and more appropriate institutions for the performance of policy functions in the world arena. Such efforts, however, if they are to be most effective, should be made but integral parts of a more comprehensive, incremental endeavor to reshape the whole of the features of global constitutive process, including the processes of the constituent communities, for the improved performance of the necessary functions. The problem of establishing and maintaining an appropriate global environment is just as indivisible and all-pervasive as is the problem of maintaining the general security against military attack. Neither problem is likely to be solved either by partial, halfway measures or by utopian schemes that would shatter existing processes and begin anew.

The most fundamental approach to new alternatives will seek, at both global and lesser levels, systematically and deliberately to improve performance, in every available structure of interaction, of each of the seven policy functions described above. When basic community goals are clarified and kept constant, many different structures of authority may serve with equivalent effects in facilitating performance of the necessary functions. Some of the implementing, ancillary policies that might be sought in the improvement of each function may be indicated:[t]

Intelligence: dependable, comprehensive, selective, creative, available.

Promotion: rational, integrative, comprehensive, effective.

Prescription: effective, rational, inclusive.

Invocation: timely, dependable, rational, nonprovocative.

Application: rational, contextual, uniform, effective, constructive.

Termination: prompt, balanced, effective, ameliorative.

Appraisal: dependable, continuing, independent, contextual.

When consideration is given in detail to improvement of the application function for minimizing losses from particular injury, attention might extend beyond judicial applications for fixing responsibility for injury already inflicted to a whole range of potential sanctions for serving various particular subgoals embraced within the larger policy of minimizing losses. These more particular subgoals include prevention, as long-term efforts to minimize the occasions for injury; deterrence, as precluding injury immediately threatened, restoration, as putting an end to injuries already in process; rehabilitation, as the short-term binding up of wounds; and reconstruction, as the longer-term redesign of the situation to preclude future injury. The range of potential sanctioning practices for serving these subgoals obviously infuses the whole of the larger community social process.

The task of highest priority for all genuinely committed to the goal values of human dignity is, of course, that of creating in the peoples of the world the perspectives necessary both to their more realistic understanding of their common interests in relation to the environment and to their invention, acceptance, and initiation of some of the many equivalent measures in constitutive process that might better secure such common interests. It is the message of the maximization postulate that men act, within their capabilities, to enhance their values. If this Conference makes its appropriate contribution, that contribution will be in increasing the capabilities of men for preserving and enjoying their world.

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WORLD PRODUCTION AND ITS DISTRIBUTION

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Because the progress of economic science has permitted better definition of the concept of gross national product and measurement of its annual growth—that is, practically speaking, since the Second World War—the wealth of nations is no longer considered as a gift of nature, climate, race, soil, or subsoil, but the result of certain historic conditions that have led all the nations to the organization of their productive forces at various levels.

Certain countries have profited from historic circumstances in developing and enriching themselves, while others have been subjected to restraints that have prevented them from attaining this level of development.

Without going into the historic roots that have created this gap in the course of development of nations, which has split them into two groups—that of the rich and well-developed nations and that of the poor and underdeveloped—without, furthermore, discussing the ethics of the rich, industrial societies, their human and moral results, and their purposes, one must recognize that this society, called "technological," which dominates the world, must be better managed, in the interest of each and every man on our planet. Some statistics show very well the absurd concentration of wealth in certain limited zones of the world while most of the people remain peripheral or marginal to the dominant economic system.

A small number of countries, where 20 percent of the world's population live, possess 85 percent of the world's wealth. The average income of the inhabitants of these countries is above $1,000 annually. These countries are concentrated around the North Atlantic, the Soviet Union, South Africa, Australia, New Zealand, and Japan. Their total production in goods and services is more than $2,000 billions, of which one country alone—the richest, the United States of America—accounts for 40 percent, or $800 billions.

All the rest of the world, represented by the underdeveloped countries, where 80 percent of the world's population live, possesses only 15 percent of the world's wealth—that is, $300 billion—and the mean income per inhabitant is below $250.

This concentration of wealth on one side and poverty on the other reflects an enormous distortion in the map of the world's production (FIGURE 1). It has thus become commonplace to speak of the tremendous gap that separates the rich industrial countries from the poor and underdeveloped ones. One no longer even speaks of eliminating this gap because it seems a utopian task. Rather, one speaks today of throwing some bridges over the abyss that separates the two groups situated on either side of this abyss, in addition separates these two worlds in every aspect, economic, social, and political, creating an antagonism so deep that it is putting the peace and security of the entire world in peril. What is more serious is that this situation, far from easing, is becoming more tragic because of the disparity in the speed of growth of these two worlds, which is constantly widening the gap. With the Con-

ference of Bandung, which took place in 1955, and at which the economically dependent countries became conscious of the reality of their socioeconomic situation, was born a new entity called "The Third World." The Third World is now in its greatest economic, social, and political crisis since the Second World War.

Faced with this dangerous situation, the United Nations established, beginning in 1960, a plan called "The Decade of Development," in which was noted the need to multiply every effort, on a national and international scale, in the struggle against worldwide economic imbalance in order to promote the underdeveloped regions. But, after ten years and in spite of all the efforts that have been made, the first "Decade of Development" may be counted a "Decade of Disappointment." It is true that a certain number of well-provided countries have collaborated to speed the dangerously slow development of these

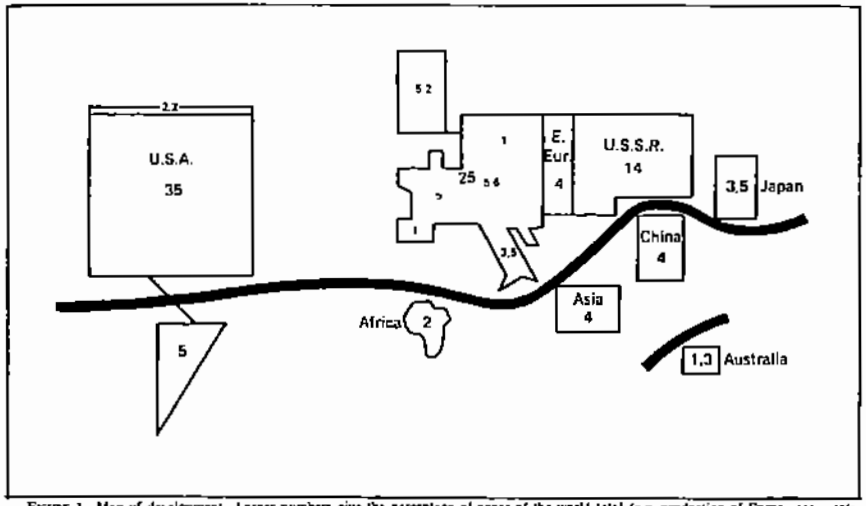


FIGURE 1. Map of development. Larger numbers give the percentage of zones of the world total (e.g. production of Europe represents 25 per cent of the total). Smaller numbers give the share of certain countries (e.g. Italy: 3.5 per cent). Gross national product of the industrial countries: 85 per cent; of the Third World: 15 per cent.

rebellious peoples: this was the beginning of international cooperation and of technical assistance for development. Unfortunately, all these efforts were made without enough coordination and, above all, in the absence of a real *policy* of development. As the former Secretary General of the Conference on Trade and Development, Raul Prebisch, has written, "The Decade of Development is being made without a policy of development." It cannot be denied that the crisis of the Third World and of its frightening economic lag is, above all, the product of a mistaken attitude of not wanting to recognize that true development is an essentially political phenomenon. The very notion of development always implies a certain conception of man and society and leads to a political choice. Without a worthwhile politics of development that encompasses a whole ensemble of measures in every sector of life and at every level of responsibility, from the individual to the universal community of all

nations, we will never have world-wide economic equilibrium for resolving the problem of underdevelopment.

This characteristic of a notion of complexity and interdependence, capable of unifying and concerting efforts for the general organization of society on a political level, is the basis for what one may call "global strategy for development."

In support of this thesis—the ineffectiveness of aid or, indeed, its veritable failure in development—it is enough to present a picture of the socioeconomic reality of the present world from various angles.

The disclosure of the work of the last Conference on Trade and Development at New Delhi has made it clear how critical the situation of the Third World is, how serious the drama of underdevelopment is. It is no longer possible to hide the fact that, despite efforts made through aid and international cooperation since the last World War, the level of life in the Third World is, each time viewed, farther from that of the well-developed and industrial countries.

All the world seems to agree on the failure of the programs of development employed in the less developed regions. It has become evident that this strategy was built on principles and systems of thought that were far from able to lead to effectiveness. Efforts are now being made in research and in sustained consideration to discover the weak points in this unsuccessful program and to conceive a new strategy of development, able to save the world from the grave dangers represented by the alarming disparity in the two worlds' pace of growth, juxtaposed as they are, but unrelated—development and abundance, on one hand, and underdevelopment and misery, on the other.

Profound analysis of this resounding setback, which turned the decade of development into one of disappointment, reveals certain very serious errors that were committed and that have made all efforts for development to amount to little.

The greatest of all these errors was to consider the developmental processes of all the world similar to those of the rich countries of the West. A kind of ethnocentrism has led the theoreticians of development to base their ideas and to build their systems of thought on conceptions of classical economics that almost completely ignored the socioeconomic reality of the economically dependent regions. They forgot that there did not exist, and does not exist today, an integrated world economy but only a Western, capitalist economy, full of contradictions, plus a socialist economy in accelerating development, alongside a network of raw material and markets in the *rest of the world*. They did not bother with the economic structure of this *rest of the world*, abandoned to the sociologists or, rather, students of folklore. But, above all, they completely forgot the inhabitants of these regions, with a traditionalist culture and so distant and so different from those who are products of Western civilization. Besides, in its frenzy of productivity, the West everywhere forgot man. The theoreticians had the notion that well-regulated doses of capital and technology—the product of Western discoveries, inventions, and innovations—would change the general picture of the structure of traditionalist cultures of the non-Western world, automatically launching all kinds of development.

The miracle did not occur, and the illusion of aid, the glib solution of the first years, was followed by disappointment and pessimism, which led to the idea that the lagging behind of the Third World is an almost insoluble problem. These countries are underdeveloped, say Western pessimists, by the force of things—biologic fatalism or geographic determinism, by natural and human conditions that prevent access to true autonomous development.

The two attitudes, the great postwar illusion and the current defeatism, strengthened by a false comparison between the rapid reconstruction of the European economy by the Marshall Plan and the stagnation of the economy of the Third World are false positions, attitudes more emotional than rational, built on no scientific foundation.

The countries of the Third World are underdeveloped not as a result of natural causes—the force of things—but as a result of historical causes—the force of circumstance. Unfavorable historical conditions, mainly political and economic colonialism, has kept these areas outside the world's economic process, which is in rapid evolution.

The secret of development resides, above all, in changing the out-of-date structures of these societies created by colonialist overlords; outside their world, these structures appear in the form called by the American sociologist Lewis "cultures of poverty," in which factors of animation and dynamics are never found but, rather, a powerful system of forces that block development and maintain the status quo, forces of economic and cultural nature. The phenomenon of development in these regions appears as a complex, at the same time economic and cultural, but, unfortunately, it was not customary to bring these two ideas together—economy and culture—as the French economist André Piatier has wisely stressed.

In truth, economic growth cannot be launched except on the basis of a certain level of cultural development: 18th century Europe, which witnessed the birth of industrial civilization, had already reached this threshold, but the Third World had not. In other words, it cannot be denied that social conditions affect economic conditions. Ignorance of these ideas, today widespread, was the cause of underestimation of social conditions on the part of classical economics; such conditions were considered a matter of sentimental feelings or claims. In the establishment of criteria for priorities in investment, already so slim and insufficient in the Third World, there was always an invincible drive to invest solely in "profitable" sectors—which is to say, in order to furnish productive machinery—in which man was always excluded from consideration. This aberration frustrated all attempts to accelerate industrialization of the countries where the weakness of the human bases and the absence of masses of consumers did not permit such economic adventure. Also forgotten was the fact that precapitalist societies are ritualistic and each action is a rite whose conduct cannot be changed by the mere introduction of a technique divorced from its ideology or of a new system of thinking. Fortunately, we are beginning to recognize that there are not two different kinds of investment, profitable and nonprofitable—those made to better human conditions by education and health.

A new science has been born, economic psychology of somewhat wider vision than that of classical economics, and through which is being formed, for example, an economics of education, which considers education an essential instrument to the formation and growth of human capital. It is by this means that the international policy of development should begin, because only the labor of men makes wealth. Economic dynamics occurs in direct ratio with the quantity and quality of this factor of production—man, the motor of the economic machine. Economic factors are put into motion only

by the brains of men and the will to organize a more advanced economic world, as Jacques Dibs has written in *Le Monde*. But brains, those factories sparked by creative energy and imagination, were almost always unemployed in underdeveloped countries. International plans for development had in mind the equipping of other types of factories, which tended to further the economic interests of the giver rather than that of the country receiving aid.

The nations that have for a long time been politically dominated by foreign powers always mistrust certain types of aid, in which they suspect hidden intentions to dominate. The West must give ample proofs that it has changed its colonial mentality in order for its cooperation to be accepted without reserve by the starving masses of the Third World. It is not enough to *have* more in order to aid others; one must *be* more—that is, it takes greatness to know how to give. The West, which—unfortunately—holds its civilization the only worthwhile one and tries hard to impose it on the whole world, setting the example of the wealth of its accumulated innovations produced by the material development of what is called the "great postindustrial society"—has not such fine things to show in terms of moral or spiritual development, things that people in search of a new philosophy of life could admire and adopt in the process of making dynamic social progress. A thoroughly reformed world leadership, as that philosopher of economics, François Perroux, points out, implies that the leaders have become capable not only of changing the world materially but also of offering a model of new men, or free men. And, paying very dearly for a still precarious political liberty, less developed nations are afraid they will fall back into a state of total servitude confronted with technocratic societies that appear, as a general rule, too domineering. One cannot make real social progress if the people are not liberated from moral and spiritual underdevelopment. This leads us to the statement, fraught with consequences, that certain well-developed countries are, in fact, as Louis O'Neil says, "rich underdeveloped countries." And from this fact it may be easily deduced that the condition for balanced development of the world is the development of man—the formation of men capable of and responsible for establishing a real dialogue between the two worlds—that of abundance and that of poverty—which, today, do not listen to each other and understand each other less and less.

In spite of the extraordinary progress of the techniques that have created polar masses in the center of wealth in the rich and well-developed countries, this prosperity, concentrated in the poles, has not radiated to the periphery of the world's economy, where two-thirds of mankind live, excluded and deprived of the benefit of this technology, of which it has learned through the means of communication and information so widespread throughout the world.

To understand what a global strategy of development must consist of, we must first of all define, with precision and clarity, the notion of development. The world has always lived under the force of myths or governing ideas, and the great myth of the 20th century is "development," as "liberty" was that of the 18th. How did we arrive at that notion of development? It is linked to the idea of progress, a new idea, because until the end of the Middle Ages it had no part in the repertoire of current thought. Man then lived in a world considered finished, therefore unchangeable. Sociology of the time was concerned with immobility. The idea of progress, that is, of changing the world, was born in the modern world with the philosophy of Spencer and Hegel. Spencer called progress "the passage from the homogeneous to the heterogeneous," and Hegel defined it as "the dialectic process of history."

This progress is made by continual evolution or by breaks with the past or transformations that provoke radical change. It is the passing from the quantitative to the qualitative that can serve as a scientific definition of the word *revolution*. The first industrial revolution followed the myth of progress. Next was formed the myth of wealth or, better, of the growth of wealth, based on the economic conceptions of Lord Keynes, centering around the idea that, in maximizing the productivity of labor and capital, we would achieve the promotion of progress and wealth everywhere in the world. This distribution of wealth would be made automatically by that force called by Adam Smith "the invisible hand," which, in the liberal economy of *laissez-faire*, would be occupied with promoting the economic balance of the world. The Manchester school of economics assured us that the economic specialization of classes and countries would benefit all mankind with an increase in wealth and result in a realm of universal abundance.

This myth, unfortunately, proved false. The invisible hand has never acted in the interest of humanity, and the visible hand of dominant groups and the privileged has always reserved to them the rewards, leaving in misery and nakedness the great marginal masses who today constitute what is called "the populations of the underdeveloped countries." Underdevelopment, however, is not the lack of development but the product of a universal type of ill-conducted development. It is the abusive concentration of wealth—especially in this historical period dominated by capitalistic neocolonialism, which has been the determining factor in underdevelopment of a great part of the world, the regions dominated precisely as political colonies or economic colonies.

In view of the limitations of this notion of the growth of wealth as a solution to the problems of the world inherent in the idea of maximization of production, another myth was born—that of development based above all on the utilization of natural and human resources. The superiority of the notion of development over that of the growth of wealth and over that of "progress," is that *development* implies both the growth of wealth and social change, both in the service of man. Development is the development of man, which is why the Secretary-General of the U.N., U Thant, is correct when he condemns the distinction made between economic and social development. There is only one type of real development, development of man—man, the creator of development and the beneficiary of development. The workshop of development is the brain of man. It is the brain of man that must flower in the use of the products put at his disposal by development.

It must be recognized, however, that the idea of development, although more complete than earlier notions of progress, is not yet entirely detached from emotional prejudices and is not yet scientifically precise. If development is the passing from a lower to a higher human level, we are not yet unanimous on the criterion of value for determining these different levels. The notion of development does not imply inevitable improvement in the human condition or greater happiness for man.

There is, in truth, progressive and regressive development—or, rather, both positive and negative aspects are included in the complex of the idea of development. For example, if man frees himself from natural constraints through technological development, by machines constantly more perfect, he is, on the other hand, shackled by other types of constraints. Development, therefore, does not mean liberty. Man chained in a mechanical network is indeed the symbol of industrial or postindustrial civilization where there is no longer freedom of choice because he is always governed by the machine.

There is no longer the right of voicing hopes, because hopes are inculculated from without by the subtle system of publicity, which is part of the consumer civilization in the so-called well-developed countries. An example that sadly reveals the situation of the well-developed man is the advertisment of a great store in a great metropolis that says: "If you don't know what you want, it doesn't matter—enter; we have it."

The contradictions of development are several. Development means both change and discipline. But discipline sometimes prevents change. The conservatism of societies that have achieved a high degree of development makes them consider themselves the ideal model of society to the point of combating the desire for change. Unequal progress in the various sectors of society is one of the causes of the grave crisis in the contemporary world. Dissemination of information on a huge scale allows the less-developed peoples to be acquainted with the images of prosperity, indeed of abundance of the great, dominating centers of the world, with their modes of life and their habits of consumption, and they despair of being able to reach that level; hence, dissatisfaction and revolt.

The old conflict between the aspirations of man and the means of satisfying them intensifies constantly when the image of the great centers is projected in the poor and underdeveloped countries. The contradiction that one augments wealth by raising production is not less serious, because this increase in production generally ends in a fall in prices, and, therefore, checks efforts for development.

Technological development is full of these contradictions, for, in reality, technology has no ethics; it is neither good nor bad, and it can therefore be used for good or for ill—to create progress or to prohibit progress. Until today, technology has worked more against the development of the Third World than in its favor.

To complete the econometric analysis of the process of development of the Third World, we must stress that the increase of five percent in universal development, decided on as a minimum objective for the decade of development, has been attained in only a quite restricted number of countries of the Third World. In fact, the average increase achieved in 54 countries—where 87 percent of the population of the Third World lives—has been only 4.5 percent. It must not be forgotten that the increase of population in these countries is the highest in the world—around three percent—which leaves a gain of only 1.5 percent a year, a ridiculous amount.

Among the factors capable of explaining the failure of plans for development of the Third World, one must stress the following points:

(1) What has been called "international aid" has been insufficient, badly distributed, and badly applied. The U.N. recommendation according to which the rich countries devote one percent of their gross national product to international aid has never been followed. The total of all forms of aid—including gifts, bilateral and multilateral loans, and private investments in the Third World, which has never been enough—far from increasing, is in fact decreasing. Since 1961, transfer of capital from the rich countries to poor countries (which once grew to 15 percent yearly) has leveled off and, in comparison with the income of the rich countries, has probably decreased.

(2) The various structures of the underdeveloped countries bar the necessary changes for the true process of development. It is, above all, traditional distribution, based on an unequal system of ownership of the earth and

on other built-up privileges, that rules out the rational use of the forces of production.

(3) Political instability, the result of tensions and disturbances caused by governments that do not truly represent the national interests of the great marginal masses of the Third World, spur neither foreign investments nor the reinvestment of profits realized in these countries.

(4) The absence of teams of qualified and capable workers constitutes another factor limiting economic expansion and utilization of modern techniques of development.

The absence of plans for development that are not just a kind of visiting card of a government that has no real rapport with the disparate measures and thinly spread initiatives of that same government acts as a negative factor in the economic development of the underdeveloped countries.

(5) Partial development, by application of capital to the more profitable sectors of the economy—above all the obsession with industrialization without the parallel development of agriculture—is also one of the most serious factors blocking the process of development, as has occurred in certain countries of Latin America, for example.

(6) The tendency to exterior imbalance, caused by an always unfavorable balance of trade (the familiar problem of the relationship of the prices of raw materials and those of finished goods) a tendency that we have not been able to lessen despite concerted efforts of countries producing basic raw materials during the two Conferences on Trade and Development that took place in Geneva and New Delhi—continues to weigh crushingly on the countries on the economic periphery and those of economic dependence.

There are many other factors produced by an absence of rational criteria, of categorical options to choose among or absence of actions to undertake, that have kept the introduction of the Third World into the economy of the world at large far from accomplishment.

The problem of underdevelopment is not a problem of these countries alone, but a universal problem that has no solutions except on an equally universal scale. To live in luxury in a world where two-thirds of mankind huddle in misery is not only dangerous, it is criminal. The social tension in which we live today is most often the product of this well-known social injustice—well known to the submerged nations once they have learned the socioeconomic reality of the world. In the phase of the history of man during which we live, a phase of transformation—essentially characterized by various explosions—the psychological explosion of the exploited nations is no less dangerous than the atomic explosion that opened a new era on our planet.

To struggle against this discrimination, which divides the world into two—a minority of nations in dynamic expansion and a majority in stagnation—we must conceive a true policy of development, an effective strategy for global development, with the goal of giving value to mankind throughout the world.

The task is immense, but it is urgent. In the years to come we will see either the economic integration of the world or the physical disintegration of the planet. Peace depends more than ever on the economic equilibrium of the world. The security of man is more important than national security based on arms. This idea, unfortunately, has not passed from theory to practice, and the great powers always depend on arms and spend $160 billion

for what they call their "national security" and devote only $8 billion (5 percent of the earlier figure) for universal security through the development of man.

To be realistic, global strategy for development must be based on a premise. We must make every effort to promote the conversion of the world's war economy to peace economy. We must, however, recognize that the current political situation of the world, with the reigning ideological antagonisms and the mutual distrust among the great powers, does not allow us, in short, the establishment of this economy of peace. We must content ourselves with obtaining the maximum of expendable funds for peaceful investments, remaining aware that a great part of disposable income will assuredly be—and be for some time—wasted in the armaments race.

The struggle against underdevelopment will for a long time be carried out under a system of penury; we must, therefore, plan to organize this penury to achieve the maximum of benefits in terms of development. This implies, first of all, a new world-wide political consciousness of the fact that the problem of underdevelopment is common to all the countries of the world—to the rich and well-developed countries and to those that are peripherally developed. The responsibilities in this struggle must, therefore, be shared by the two groups in the framework of a global strategy. To the underdeveloped countries themselves belongs the greater responsibility and the greater effort but these countries cannot get out of the vicious cycle of underdevelopment without international cooperation on the part of the more advanced countries, which have a surplus of capital and techniques and knowledge. International cooperation is thus indispensable to the effectiveness of this effort of development. The strategy also must be global in respect to the various measures that must be taken and the several sectors that must be touched on. We cannot limit ourselves to developing one sector while we ignore measures vital to the parallel development of others, and risk the distortions and restrictions that would compromise the totality of the process of development. Such is the case when nations aim at industry at the expense of agriculture; we soon see that development is blocked.

A global strategy of development must respond essentially, as Raùl Prebisch stressed, to the three great problems for which a rapid solution must be found:

The struggle against the persistent tendency to exterior imbalance.

The struggle against the lack of saving.

The struggle against exterior vulnerability of peripheral economies.

We must conceive an entirely new plan for international trade that would permit the underdeveloped countries to intensify their exports at competitive prices on the international scale. It is clear that if exporting raw materials and basic products is daily increasingly difficult because of technological progress that causes a relative diminution in the consumption of these raw materials, there remains the possibility that the new lands could export finished products. Unfortunately, the industrial countries have so far resisted the yielding of the smallest place to the peripheral countries in the world market for industrial products. It is true that the rich world is beginning to have some misgivings in the face of protests and threats from the poor. At a recent congress in San Francisco, the President of the Chase Manhattan Bank, David Rockefeller, declared: "If we do not succeed in arresting inflation without at the same time reducing trade and investment, we will run the risk of provoking such bitterness among two-thirds of humanity that it will take several generations to restore contact. Meanwhile, we may find ourselves forced to live in isolated citadels." He has also predicted "the most terrible disasters in the world if nations do not open their frontiers wider to the products of poor lands." What Mr. Rockefeller said has been stated and restated by us for the last 20 years in the following formulation: "We cannot live in a world divided between, on one hand, two-thirds who do not eat and, knowing the causes of their hunger, revolt, and, on the other, one-third who eat well—sometimes too much—but who can sleep no longer for fear of revolt on the part of the two-thirds who do not eat."

During the Second Conference on Trade and Development, held in New Delhi, the industrial countries nonetheless were deaf to the claims of the poor countries in regard to international trade. We must also have a new view concerning capital investment in the Third World. The underdeveloped countries much distrust speculative capital not directed to the interest of global development but, rather, to the particular interests of certain products and certain groups that will garner the benefits. Investments must be made in obedience to real plans of economic development, conceived in the interest of the people who are to participate in the realization of these plans. It is true, and it is fair, that the benefactors or the investors know these plans and begin, in part, to make studies capable of judging their viability and productivity. But we must not confuse these studies with unwarranted interference in the political life of countries considered the beneficiaries of these investments. The study of a country's policy of development is already being practiced by such financial institutions as the World Bank, but, considering the delicate responsibility that lies in examining a plan with contradictory interests at work, it is preferable that this judgment be made not by the investors themselves nor by the beneficiary country but either by groups of independent experts or by a consortium of investors from the various countries participating in the project or the plan of development in any country.

Another important aspect of a global strategy is that of fixing limits between the obligations of recipient countries to reinvest in development the capital given and the obligation to raise the level of consumption of their people. Each nation must have the right to study the problem in the light of its own social situation and to establish norms compatible with the biological and psychological tolerance of its masses. It is in this way that criteria or directives for plans of development are established. Furthermore, he who speaks of "plans" says also "discipline in development," and this discipline imposes rules that both parties must obey.

In the strategy of development we cannot limit ourselves to the conception of short-term plans but must also consider perspectives, that is, long-term planning. This does not mean that we are obliged to make prophecies or foretell results, but we make prospective analyses that will permit the formulation of possible and desirable outcomes and allow for working toward them. There too, it is up to the most competent men of every country to know what their aspirations are and how to labor to satisfy them. Global strategy implies action at all levels and in all directions, but it is plain that a criterion of priority must be set up in accordance with the disposable means and the most urgent needs.

In my opinion, one of the highest priorities for the entire Third World is that of *human development*, that is, the creation of men responsible for and capable of starting global strategy on its way. We must integrate into one world the side-by-side bits of contradictory economies; this is the business of

tomorrow's man. To bring this task to a successful conclusion we must educate this type of man.

The problem of developing the Third World, and even the entire world, which in some aspects is still underdeveloped, is above all a problem of developing men. If the industrial revolution dominated the 19th century, it is cultural revolution that must dominate the 20th; we must strive for creation of a culture capable of finding real solutions to the great problems of mankind. In this new culture, science and technology will certainly have a great role to play, but they cannot comprise the whole image of that culture. There are many other, equally important, values. We must not forget that science is not wisdom. Science is knowledge. Wisdom implies knowledge *and* judgment. And on this point—on the judgment of values—we are far from having a clear idea of the hierarchies of factors to be brought into play in order to build a global strategy for development that does not separate the economic from the human but, on the contrary, considers man—groups of men, all of humanity—the final goal of development. Father Lebret spoke of the urgent necessity for proceeding to the conversion of man, that is, on one side to change the mentality of power and domination of some and, on the other side, to change the mentality of fatalism and conformity of others, by a mentality nourished with the taste and desire for progress and with the will to acquire the benefits of true development, as well. In this new view, it is instruction, education, and human development that must constitute the requisite investment and, surely, the most profitable investment, for unleashing the rush of development. It is evident that, in order to measure the profitability of investments of a cultural nature, we must use a norm of economic calculation entirely different from that we now employ: thus, in the light of efforts made in certain countries, we may realize, as the economist André Piatier has declared, that the profitability from intellectual investment is infinitely superior to that obtained from the equipping of machines, tools, or works. In recent years, efforts towards development have begun to be obtained in this direction.

In the working budget of the Third World, 20 to 25 percent of funds are now devoted to education. Further, the agreed-on effort by the industrial countries in the policy of international aid—after appropriations for the purchase of armaments—is the mobilization of human resources; education, food, and health, which have the highest priority. In spite of this relative effort, we have progressed little in this domain, and the more serious problems of the underdeveloped countries remains today that of the educational level of the inhabitants, considered as factors in production. Besides, credits intended for this sector are in reality quite limited in relation to the huge task of developing men at all levels, from the education of the masses to the formation of élites—specialists and experts in adapting foreign technology to domestic needs and realities. Nor must we forget that, in underdeveloped, and hence undercapitalized, countries, planning—as an Indian economist Ika Paul-Pont has emphasized—has for its primary objective the organizing of poverty to spur development. It is, thus, with the budgets of poverty that the rescue from ignorance and illiteracy of these great masses of mankind—the damned of the earth—has been attempted. It is a difficult task, and is made much more difficult because we do not yet know the means appropriate to such a complex undertaking. We realize again that it is not enough to assign credit, large or small, in order to have worthwhile training, the type of education adequate to the real needs of these countries. The methods of teaching, the educational

programs put into practice have always been ill-adapted to the social context of the economy of poverty in which traditionalist societies are mired, with their archaic social structures and their forces of production strangled by the domination of alienated élites whose interests do not correspond with those of the disinherited masses. The mere transfer of culture—that is, the exported utopias, in terms of education—can never provide a means of development of the kinds of men the Third World needs to expand its economy in a human sense, one that respects the cultural roots of the people. It is being asked more insistently whether development is, indeed, dehumanization, in this frenzied search for wealth in accord with the formula instituted by the West to maximize revenues instead of maximizing the mental energy that more quickly enriches the lives of men and can give them much more happiness. The only way of making the world develop in balance is to look for the means of integrating scientific and technological values into the heritage of values representative of other, non-Occidental, civilizations—but not under the dangerous banner of domination, which everywhere provokes revolt. An education for free men; that is what the peoples of the Third World aspire to. And this presupposes a pedagogy of freedom, one that liberates them from the constraints of nature and also from the constraints of other groups of men—of all types of domination. This means that they must be educated to free themselves economically, politically, and spiritually. What has been done in the Third World until now has been far from attaining that objective. Until today, culture represented in these countries a privilege, an extension of the other privileges of the dominant minority. In most of the countries on the way to development, not one percent of the youth can go to the university, and the university in these countries is, in general, merely an apparatus for the adoption of a false culture, an importation, where élites are formed. The universities are only centers of professional training in the model of the halcyon days of the *Belle Époque*, where a sterile culture is served up, one incapable of creative and renewing stimulus. Students leave these universities with a mentality prefabricated to accept and defend the status quo that has given birth to these privileges, privileges that must be defended at all costs, even that of underdevelopment and national servitude. It is, thus, a type of particularly antidemocratic culture. To make a popular type of education available would be to unleash an irresistable movement toward social change to which the dominant minority, hostile to the idea of worthwhile educational reforms, is opposed. The true reformers of teaching methods in many underdeveloped countries are regarded as dangerous elements, subversive to established order, dangerous to the maintenance of these *democracies without men*, where a handful must know everything and rule everything and the masses must know nothing and must always obey.

Confronted with the sharp crisis that the West is undergoing, always based on an economy of war, we have been led to believe that we must conceive a human development for the new countries based instead on an economy of peace. But to achieve it, we must mobilize mass public opinion with modern methods of communication, public opinion on the part of masses capable of creating a mass culture sparked by an egalitarian ideology. This mobilization of public opinion can be created only by an intercommunication quite different from the unilateral methods of information by which the instructors permitted only the learning and the ideas that interested the dominant group to filter down to the masses. The director of UNESCO, René Maheu, told me recently that he

wanted with all his might to expedite the world-wide revolution by education. This is the great objective of education in the countries of the Third World, where already the insight has occurred that only revolution can achieve real solutions to the problem of the marginalization of these people. But this revolution must be prepared for, or, better, men must be prepared to make it. One may improvise a revolution that, in general, will be abortive, but one cannot improvise a revolution that would be an act of thoughtful creation, as Louis Armand has pointed out in his "Plea for the Future."

To conclude the "scandal of underdevelopment," let us cite the expression of Jacques Austruy: the only road onto which one must rush is that towards validating and mobilizing one's human capital by revolutionary methods. Unless this spiritual revolution is made, all international aid—gifts, loans, whether bilateral or multilateral—private investments as well as the alteration in the terms of international trade and the stabilization of the prices of basic materials —all these trifles will not end in plucking the proletarian countries from their chronic misery, the hideous inheritance of colonialism.

Underdevelopment is a kind of undereducation, undereducation not only of the Third World but of the whole world. We must educate and develop the spirit of men, which has everywhere been deformed. Only a new type of man, daring to think, daring to reflect, and daring to act, can realize a true economy, based on human and balanced development.

I would emphasize that a global strategy of development *must not* be considered a semantic formula, a play on words that could cover the ineffectiveness of an action until now badly performed. The strategy must correspond to a new conception of the world's economy, which must be totally reviewed. Putting it into effect will require a world-wide movement to convince the economically dominant countries of all the profit they will get if they direct their efforts toward a plan of true international solidarity and to convince the countries in need of aid of the necessity of proving their firm wish to develop their nation and to become equals in the economic community of the peoples of that world.

FROM ECONOMIC TO SOCIOECONOMIC DEVELOPMENT

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The "Economicist" Concept of Development

There is no doubt that human life in the more prosperous countries has changed very rapidly during the last few centuries. The availability of many forms of comfort has increased at a high rate. To a considerable extent, the forces behind this change are increased scientific and technological knowledge manifesting itself in the large numbers of new goods, in improvement in their qualities, and in a continuous change of production processes using increasingly ingenious and increasingly complicated means. A very considerable portion of these innovations have been created by individual minds and by individual acts, in which the individual was guided by personal interest and personal gain. Inventors, engineers, managers, and owners of means of production were moved largely by such personal motives. Scientists' and technicians' work was for quite some time one-man work, and so was employers' activity. To be sure, they cooperated in groups of increasing size, but for a long time this cooperation was based on contracts that could be easily discontinued. And even though groupings of individuals of increasing size came to play their role, for the period under review the process of our society's development was described as a process in which each person pursued his own interest. Attempts were even made to prove that such an attitude was conducive to the maximum of satisfaction for all and was creating the "best of all conceivable worlds." This was typically the attitude of economic science, represented by its "father," Adam Smith, and continued to be the approach adhered to by economists for a considerable portion of the 20th century. The political representatives of the élite in power in most modern countries continued even longer to believe that individualism had to be the basis of economic development, stressing the role of individual responsibility as an invigorating force fostering further development of human society. A strong belief in private enterprise and economic freedom prevailed, which were thought to take care automatically of everybody's interest, providing employment and a living to all, with incomes reflecting social justice: everyone got from society the equivalent of what he was giving to it. We will call this view the "economicist" concept of development. For a long time, this view was held especially in the United States.

Reactions in Europe

The economicist view was held in Europe also, but reactions to it came earlier than in the United States. The first reactions came as early as 1850, especially on the part of Karl Marx and his followers. For a considerable period their influence was limited, however, to the workers' world, where they gave rise to the creation—or the reorientation—of trade unions and of

political parties with only slight influence. Some influence penetrated into parliaments, however, and in the second half of the 19th century a beginning was made with social legislation, tending to interfere with complete economic freedom in favor of some of the very weakest social groups, such as children, and some affected by accidents or professional illnesses. In the more advanced countries, the income tax was introduced. Socialist ideas penetrated into the working class to the extent that the Pope was induced to launch the encyclical *De rerum novarum* (1891). One of the features of the Roman Catholic approach of these days was to recognize the right of every family to a minimum of decent living.

More important changes took place during or immediately after World War I, which led to the two Russian revolutions, of which the second brought the nondemocratic wing of the socialist movement to power in Russia and at the same time accentuated the split in that movement between the democratic and the nondemocratic wings, later also known as the *social democrats* and the *communists*. The Soviet Union established a society that did away almost completely with economic freedom and to a large extent with private enterprise. In the most advanced Western European countries, the public sector, social legislation, tax legislation, and some other types of restriction on private enterprise and economic freedom were pushed, leading to the form of integrated socioeconomic development later known as the *welfare state*. One of the limitations observed was that most workers, or even trade union leaders, were not particularly interested in what is nowadays called "participation" (in those days "industrial democracy" or "codetermination").

Reactions in the United States

As already stated, in the United States the philosophy of free enterprise was adhered to for a longer period. It was only in the Great Depression, after 1929, that the belief in the automatic cure of all evils by free enterprise received a bad shock, simultaneously with another shock in Europe. In the United States, the New Deal brought a number of limitations to freedom and introduced social legislation and other forms of government intervention at a scale until then unknown. In some respects the United States went further even than a number of European nations. This was partly due to its higher average level of income, which permits some types of interference to be stronger; thus, the ratio of direct to indirect taxes is higher in the United States than in most European countries, and capital gains taxes do not exist in many European countries.

The Great Depression also brought the recognition of the necessity to regulate untable markets, especially numerous in agriculture, and the need of an anticyclical fiscal policy. Elements of planning were introduced, and not only in the public sector. On the contrary, planning had its greatest victories in big business.

The Second World War reinforced the understanding for the necessity of government guidance, at least during emergencies, and developed several techniques of intervention. Some type of government planning, whether of the rather penetrating French type or the much looser Anglo-Saxon type (Council of Economic Advisers in the United States, Cabinet Offices and, later, "Neddy" in Britain) entered the scene in almost all Western countries.

Back to Economicism

The end of World War II brought some reinforcement of economicism, however. In the United States, the untimely dissolution of the Office of Price Administration—leading to world inflation—was one example; in Western Germany, as a reaction to Hitlerism, a revival of slightly old-fashioned ideas under the beautiful name of "social market economy" brought back some economicist attitudes, which, to be sure, helped to rebuild the German economy (the *"Wirtschaftswunder"*). Even so, anticyclical policies continued and were remarkably successful; social insurance was expanded further, and for quite some time reconstruction in Western Europe required some forms of intervention, including macroeconomic planning imposed by the Marshall Plan! After the reconstruction period was over, by 1960 or thereabouts, there was an increased interest for some economicist elements, strengthened also by some difficulties experienced by Eastern Europe, which had been brought under Soviet domination after World War II. With increasingly complicated production processes and higher standards of living, Eastern Europe needed another mix of planning and freedom, or, at least, a larger number of levels of decision making. This was brought by some of the well-known reforms, exploited by free-enterprise propaganda. A number of American authors introduced the concept of "market socialism," without stressing sufficiently that for many activities, even in the West, markets must be regulated and that a considerable sector still requires more rather than less planning. This is true in particular for activities causing ecological disequilibria (air and water pollution, external effects of drugs, etc.). It cannot be denied, however, that around the '60s there was a tendency again to forget about a number of "social" issues. We will discuss their nature and their role in the subsequent section of this paper.

Nature of Social Elements

Scientific interest in "social elements" in human life has developed, as usual, much later than the intuitive interest shown by society. While economics faculties were given independence from law faculties around the '20s in the more advanced countries, sociology or social science faculties were a much later development. While the League of Nations' Secretariat had a Financial Section and Economic Intelligence Service next to a number of political and technical units, it is only in the United Nations' Secretariat that, even though the International Labour Organization was the oldest "specialized agency," the need was felt to have a Department of Social Affairs separate from the Department of Economic Affairs. As late as 1964, the United Nations Research Institute for Social Development took its modest place in the United Nations family of institutions, reflecting an increased pressure from the Social Commission (now Commission for Social Development) to introduce "social elements" into development planning. This is not to say that many social issues had not already been studied scientifically long before, but it illustrates the lag in comparison with the study of economic problems.

There are *three definitions* of what constitute "social aspects of development." The oldest and, in my opinion, best definition is all measures to correct complete economic freedom. In this sense we have seen the establishment of

Ministries of Social Affairs and similar institutions in order to moderate laissez faire. The second definition has come into use, it seems, in an attempt to define some fields or sectors in which the activities of a social character were concentrated. It is a summing up, as of health, housing, education, nutrition, community development, and perhaps a few other matters. My rejection of such a definition is based on the fact that not all activities directed at better health, better housing, education, etc., are in fact meant to be included. Large portions of these activities are carried out by individuals acting in their own interest, as under laissez faire. It is only to the extent that the results of income distribution under economic freedom have to be corrected that measures on behalf of weak groups are taken in these fields, and this means that the first definition of social aspects is more satisfactory. A third attempt to define social, as distinct from economic, aspects identifies social aspects with the ultimate aims of development and economic aspects with the means applied to attain the aims. While this structure of a development policy, that is, the distinction between aims and means, is very important, we have already got terms to make the distinction ever since the Swedish school started giving attention to it,[a] and I see no need to change the terms chosen. This is why I prefer the oldest definition. I should add that there is perhaps no need at all to use the word social in contradistinction to economic. We may simply speak about socioeconomic development, thus using a term introduced long ago by Cassel[b] simply to indicate the difference between the economics of society and business or enterprise economics.

In any case, it has long been admitted that the aims of development should be the maximum welfare of the population as a whole over a long period and that the elements of welfare are all those things that make people happy. Among them are things of a material nature and of a nonmaterial nature and things pertaining to personal needs as well as to social needs—that is, needs of groups or needs springing from a *comparison* between one individual and others. The length of the period is the most difficult aspect of defining welfare; elements involved here are that longer-term interests of one individual should not be forgotten vis-à-vis short-term interests, but also that the distribution between generations should be observed.[c]

Although the economicist view does imply the care for elements of an individual character, the integrated socioeconomic view, while not forgetting the importance of personal incentives and initiatives, brings in the elements of comparison and hence of distribution. For the satisfaction of the poorer groups in any society, the distribution of welfare among individuals and groups is a vital element. It is insufficient to see to it that, as *Rerum novarum* put it, a minimum of decent life is attained, or, rather, this formula is empty to the extent that what is considered decent depends on what others have. Marx

[a] Although the concepts have been used earlier by his compatriots the clearest introduction of the aims and means of economic policy (in his case fiscal policy) can be found with B. Hansen in his Finanspolitikens Ekonomiska Teori (Stockholm 1955); cf. also E. Lindahl, Studies in the Theory of Money and Capital, London 1939, p. 22.

[b] G. Cassel called his well-known textbook on economics "*Theoretische Sozialökonomie*".

[c] M. Inagaki, The Theory of Optimal Economic Growth: A Contribution, diss. Rotterdam (to be published by North Holland) made a very remarkable contribution to exactly this aspect of the problem.

spoke of a "customary standard" to establish what people think is decent. What really matters is the *distribution* of welfare (or, as the closest proxy, income) and not the absolute level or even the rate of improvement, although both of the latter have some relevance, especially in the short run. The following evidence may be quoted in support of my thesis.

1. Already within the world of labor it is well known that, upon appraising a wage offer, workers pay considerable attention to the *ratio* of that wage to wages of others. As a matter of experience, wages in one industry are kept in line with those in some standard industry, especially in the metal-working industry.
2. More generally, there is the well-known desire not to differ too much from others, as illustrated by the phrases "keeping up with the Joneses" and "conspicuous consumption" as factors of discontent among those not able to consume as much as the standard consumption pattern.
3. As an illustration we see that in recent years all discontent about society shows up in demands for *wage increase far surpassing the average rate of increase in income per capita*. If workers were satisfied that the present distribution of income is "correct," they would not ask for so much more; but they feel they are disadvantaged.
4. Accordingly, public opinion polls reflect *more* dissatisfaction with existing income distribution the *lower* a group's income is.

In conclusion, I want to state that what has been overlooked by the economicist view is primarily the widespread feeling that *income distribution is unsatisfactory*, not only under laissez faire, but even in Western Europe's mixed system[d] and Eastern Europe's centrally planned system. On the other hand, there remains a hard core of truth in the economicist view, namely the need for personal incentives.

Recent Blows to Economicism

During the last five years or so, additional blows have been given to purely economicist thinking, on both sides of the Atlantic. In Western Europe, the postwar innovation processes had come to an end around 1960, and there is an increasing feeling that improvements in income distribution have also stopped. Moreover, the desire for more *participation*, which was not widespread in the '20s, has become a new dimension in the thinking not only of students but also of groups of employees. Although in different forms, some of these desires have also come to the fore in Eastern Europe. In some respects the Yugoslav development of workers' councils has attracted much interest. Yet, for a majority of employees, it is probably still income distribution that interests them most. The difficulty surrounding the demand for added income is that it is manifested by a demand for instruments that are not, according to economic analysis, the most appropriate ones. The demands are for higher wages, whereas the instruments that may do the job are to be found in tax structures and education policies.

[d] In Sweden, the Socialist Party and the Trade Union Central Organization, published a report, "Jämlikhet" (Equality), in 1969, which reflects the renewed interest in the subject.

In the United States, similar desires have been expressed, but the problem has been complicated by its race aspect. In fact, what the United States is experiencing is a prelude to what the world at large will be facing soon: how to make up for the poor sections of society whose poverty is partly due to underprivileged positions and partly to the ensuing lag of participation in modern education and knowledge.

Two other features in recent discontent are worth mentioning. One is the tendency of some young people to despise the comfort created by technological progress. This could be a positive force for development if there were not another negative feature, a sort of modern anarchism, implying the untenable view that under the present technological circumstances one can first destroy the existing order and then start building a new one. The lack of understanding of present-day technology (in the widest sense, and including the technology of administration and government) inherent in this view is indicative of ignorance and emotion; our hopes must be for a more mature view on the means to change the society.

The Developing World

As stated in the preceding section, the world at large is the scene of similar feelings of discontent characteristic for the industrialized countries. The extreme poverty in which the masses of Asia, Africa, and Latin America are living is no longer accepted as an inevitable destiny. Thanks to the general development of science and technology, ideas are rapidly spreading to all corners of the earth and a confrontation of the poverty of the developing world with the relative prosperity of the developed world becomes more natural every day. The ideas are spreading that the growing gap in welfare is not a necessity and that the economicist view can no longer be the only basis for world economic relations.

Two features enormously complicate the problems of the Third World. One is that the attitudes of their populations are still influenced by cultural and societal elements that stand in the way of an efficient development of their economies. The *cultural* elements are those of a metaphysical origin as described, in their great variety, by cultural anthropologists. The *societal* elements are those of feudal stratification, with all the discrimination and taboos that go with it. The other complicating feature of the underdeveloped countries is the size of the problem, which has been so magnified by the population explosion, caused by the penetration of Western knowledge in the field of health before the other balancing elements of Western knowledge spread.

Even so, the essential problem of the developing countries is a repetition of the social problem in the developed world: the discovery of the neglect of what were called in the preceding sections the social aspects of development. Accordingly, we see a repetition of many discussions, first held about the Western social problem and now held about the world development problem. Most of the remedies found for at least a partial solution of the West's social problem can be recommended for the beginning of the solution of the world's development problem. I am not going to demonstrate this here: I have tried to do so elsewhere. The one aspect I want to highlight here is that again, as in *Rerum novarum*, we find those who maintain that it is sufficient that a minimum of decent living be organized for the masses of the poor.

What Lessons to be Learned?

What we have to learn from our own previous experience is that such a minimum of decent living, although desirable and necessary, will not be sufficient. What will really matter, in the long run, is the distribution of income, both within nations and among nations. Temporarily, a quick rate of improvement will satisfy the underprivileged; in the end their satisfaction will be determined by the ratio between their incomes and those of the privileged. While some differences in income are accepted as reasonable by everybody, a considerable portion of present income difference is not considered just. Differences due to explicit privileges—that is, discrimination—will not be accepted. Incomes obtained without effort will not be accepted either. There will be a tendency to ask equal incomes for people who are making equal efforts, even if these efforts do not produce the same results. This is what I think we are heading for. Economic science should try to find out how this can be attained without killing incentive. I think there are more possibilities than are usually considered among economists.

As already observed, the emphasis should be on tax systems and education activities. In regard to taxes, a shift from income taxes to wealth taxes is one of the avenues to follow. A given amount of wealth tax tends to contribute more to equality and to weaken incentives to work less than an equal amount of income tax. Because little is known about the precise reactions of the taxpayers, the shift should be undertaken step by step, so that the community can feel its way. In addition to a tax on financial or physical wealth, the possibility of taxing personal capabilities should be explored. Here we can expect only some modest first steps; thus, we may think of a special tax on persons with high academic scores. There are beginnings of such taxes in that scholarships have to be paid back at a higher annual rate by alumni who obtain good jobs than by those who obtain less good jobs.

In the field of education, the bottleneck has now been found to be the *preschool education* received in the family and the outside environment, and experiments are being made with special supplementary teaching to youngsters in the primary schools coming from underprivileged surroundings. If, along these lines, together with the already existing facilities for scholarships, the supply of trained and qualified manpower can be increased while the supply of less trained goes down, the bargaining position for income of the poorest strata will be improved and less inequality in wage and salary scales will result.*

In the international field, we should learn from experience first, something about the eventual aim of development cooperation. This aim should be to reduce the income gap between developed and developing countries. It will not be sufficient to aim at a "decent minimum" of income per capita, although for quite some time to come this aim will be sufficient. Actual living levels are so much below anything that could be called decent that both aims require the same action. Eventually, however, it will be distribution—that is, ratios—that matters.

Much more important at present is, second, what should be undertaken in the short run.

The strategies needed in the international field have recently been described

* Some further elaboration of the ideas briefly set out here will be found in J. Tinbergen, "Development Strategy and Welfare Economics," Coexistence 6 (1969) p. 119.

by the *Pearson Report*[1] and the *Report of the United Nations Development Planning Committee*.[2] It would be duplication to make a new attempt to indicate these strategies. Let me therefore briefly list only some of the most important recommendations of the latter committee, of which I happened to serve as chairman.

For developing countries the most important recommendations are:

— to increase the country's savings by 0.5 percent of gross domestic product per annum;

— to carry through land reforms (that is, putting a ceiling on the amount of land owned by one family) or to introduce a progressive tax on land and some other elements of physical wealth which can be easily assessed;

— to eliminate privileges given to some social groups;

— to improve efficiency and cooperation within the government machine;

— to reorient education and methods of education to meet the need for technicians and entrepreneurs;

— to cooperate with neighboring countries to establish larger markets;

— to improve marketing of their export products.

For developed countries the most important recommendations are:

— to make available a financial flow to developing countries of one percent of gross national product;

— to ease conditions for public financial transfers, which should attain 0.75 percent of gross national product and, by 1975, show an "aid content" of about 80 percent;

— to eliminate, in about five years, trade impediments to imports of semimanufactured and manufactured goods for developing countries;

— to conclude commodity agreements for unstable raw material markets;

— to spend, by 1980, 5 percent of their research and development expenditures on problems relevant to developing countries and to transfer 0.05 percent of their gross national product to developing countries for direct support of science and technology.

For the *United Nations system of agencies* the recommendations are that the process of development policies and cooperation be regularly evaluated, at the following levels:

— the level of the single nation;

— the level of consortia or similar groups of countries cooperating with a developing country or a group of such countries;

— the regional level (corresponding with the Regional Commissions); and

— the world level.

[1] Partners in Development, Report of the Commission on International Development, Lester B. Pearson, chairman; New York, 1969.

[2] United Nations Development Planning Committee, Report of the Sixth Session (New York, 1969).

While these evaluation processes are considered part of the administration of implementation, a group of independent experts has been asked to comment on the criteria used and the judgments passed. Their comments should be offered separately to the U.N. Economic and Social Council, where an annual discussion of progress and prospects should be held in preparation for the General Assembly. The importance of evaluation is its feedback on policies, and hence the contribution it can make to increase the efficiency of the operation.

POLICY SCIENCES: DEVELOPMENTS AND IMPLICATIONS

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The Need for Policy Sciences [a]

From the point of view of human action, scientific knowledge can be divided into three main levels: knowledge relevant to the control [b] of the environment, knowledge relevant to the control of society and individuals, and knowledge concerning the control of the controls themselves, that is, on *metacontrol*.

Knowledge of control of the environment, as supplied by rapid progress in the physical sciences, is the most highly developed of the three. Knowledge about control of society and individuals is much less advanced, but at least the social sciences and psychology constitute recognized components of science, receive significant support, and show some signs of progress. Least developed of all, and scarcely recognized as a distinct focus for research and study, is metacontrol knowledge, that is, knowledge concerning the design and operation of the control system itself.

Scarcity of knowledge relevant to design and operation of the social overall control system—which I call the public policymaking system [c]—has accompanied humanity from its beginnings. While some progress has taken place in the mechanics of control and microcontrol systems of some social components (such as corporations), the essential features of the public policymaking system continue to be beyond penetrating understanding and, even more so, beyond conscious and deliberate design.

This blind area in human knowledge has always caused suffering and tragedy, in terms of human values. But, from a longer-time perspective, the weaknesses of the public policymaking system did not matter very much as long as the operations of that system did not constitute an important variable in shaping human destiny. When most variables shaping human and social fate were beyond influence by the public policymaking system because of the absence of powerful policy instruments, bad decisions on the use of the few available instruments (or, to be more exact, "instrument images") had only

[a] Any views expressed in this paper are those of the author. They should not be interpreted as reflecting the views of the Rand Corporation or the official opinion or policy of any of its governmental or private research sponsors.

[b] I am using the term "control" in the sense of regulating, governing, shaping, directing, and influencing. "Monitoring" is one subelement of "control," in the broad sense in which I use the latter.

[c] Comparable terms are "central guidance cluster" as used by Bertram Gross and "societal control centers" as used by Amitai Etzioni. See Bertram M. Gross, *The State of the Nation: Social Systems Accounting*, London: Tavistock Publications, 1966, pp. 72–73, and Amitai Etzioni, *The Active Society*, New York: Basic Books, 1968, p. 112.

very limited impact on basic reality and therefore could not cause long-range harm.

It is this insignificance of public policymaking systems on the long-range fate of humanity that is changing, thanks to rapid progress in knowledge of policy instruments that permits control of environments, society, and individuals. New knowledge supplies increasingly potent instruments for use by mankind. The nuclear bomb and ecology-poisoning techniques and materials are but weak illustrations of the powerful policy instruments supplied by modern science. Altering the gender of children, weather control, genetic engineering, stimulation of altered states of consciousness, and emotion controls—these are only some illustrations of the more powerful capacities for controlling the environment, society, and individuals that the progress of science is sure to supply in the foreseeable future.[d]

It is the growing gulf between capacity to control the environment, society, and individuals, on one hand, and, on the other, knowledge of how to design and operate policymaking systems so they can use these capacities that constitutes the major danger to the survival and development of humanity. The emergence of *controlling man*, who exerts dominance over his environment, over social institutions, and over the very nature of human beings, makes it absolutely essential to improve policymaking systems so as to use wisely the powerful instruments at his disposal.

I purposely use the term "wisely" to emphasize the multidimensionality of required changes in public policymaking systems. Urgently needed, for instance, are new values and belief systems that meet the new global role of *controlling man*. Scientific knowledge cannot supply new values and belief systems,[e] though perhaps some of the conditions of value innovation can be studied and consciously encouraged. But science can and should supply knowledge on preferable designs and patterns for the rationality components of public policymaking systems, including rational means for improving the designs and patterns of the essential extrarationality components.[f]

In short, a main problem faced by humanity can, I think, be summed up in what I aphoristically call the Second Dror Law: [g] *While human capacities to*

[d] For a careful discussion, see John McHale, *The Future of the Future*, New York: George Braziller, 1969. For longer-range and more speculative explorations, see Gordon Rattray Taylor, *The Biological Time Bomb*, New York: Signet Books, 1968, and Burnham Putnam Beckwith, *The Next 500 Years*, New York: Exposition Press, 1967.

[e] For somewhat different and stimulating views, see Hazan Ozbekhan, "Toward a General Theory of Planning," in Erich Jantsch, Ed., *Perspectives of Planning*, Paris: OECD, 1969, and Erich Jantsch, "From Forecasting and Planning to Policy Sciences," *Policy Sciences*, Vol. 1, No. 1, Spring 1970, pp. 31–42. Completely unacceptable, in my opinion, are the naïve proposals made from time to time by physical scientists to achieve deliberate and systematic value innovations aimed at the long-range future through quasi-rational mass movements. See, for instance, Gerald Feinberg, *The Prometheus Project*, Garden City, New York: Doubleday, 1969.

[f] For an extensive discussion of the roles of rationality and extrarationality components in preferable policymaking, see Yehezkel Dror, *Public Policymaking Reexamined*, San Francisco: Chandler Publishing Company, 1968, pp. 154–196.

[g] The First Dror Law states: *While the difficulties and dangers of problems tend to increase at a geometric rate, the knowledge and manpower qualified to deal with these problems tend to increase at an arithmetic rate.*

shape the environment, society, and human beings are rapidly increasing, policymaking capabilities to use those capacities remain the same.

A large number of dispersed efforts to develop knowledge relevant to policymaking improvement do take place. These include work under the auspices of a number of new disciplines, approaches, and interdisciplines, such as operations research, praxeology, systems analysis, organization theory cybernetics, information theory, theory of games, organizational development approaches, strategic analysis, future studies, system engineering, decision theory, and general systems theory. Also important is some work in new directions within more traditional disciplines, especially economics, some branches of psychology, and some parts of political science.[h] This work supplies important insights, promising concepts, and stimulating ideas. But, in general, present endeavors to develop scientific knowledge relevant to the improvement of policymaking tend to suffer from the following weaknesses: [i]

1—Microapproach, with applications to some types of decisions but very limited relevance to the policymaking system as a whole.

2—Disjointedness, resulting in fragmented views limited to single dimensions of policymaking. Thus, systems analysis is quite isolated from organization theory, operation research from psychology of judgment, and decision theory from general systems theory.

3—Preoccupation with the rationality components of policymaking, with little attention to the fusion of rationality with extrarationality and the improvement of the latter.

4—Incrementalism, with nearly complete neglect of the problems of policymaking systems novadesign (i.e., design anew), as distinguished from slight redesign.

5—Narrow domain of concern, which neglects consideration of possible improvement needs and improvement possibilities of some critical elements of the policymaking system, such as politicians.

6—Sharp dichotomy between the behavioral approaches, which study some segments of policymaking reality, and the normative approaches, which design abstract rationality-based microdecision models. Therefore, no comprehensive approach to understanding and improvement of the policymaking system as a whole.

7—In the normative approaches: strong dependence on metric quantification and therefore inability to handle "qualitative" variables.

8—In the behavioral approaches: lack of interest in prescriptive methodology and gaps between lack of interest in application and partisan advocacy.

9—Fixation on conventional research methods and consequent inability to utilize important sources of knowledge (such as tacit knowledge of policy practitioners) and difficulties in designing new research methods to meet the special problems of policymaking study and improvement (e.g., social experimentation).

[h] For selected bibliographic references to relevant work until 1967, see "Bibliographic Essay" in Yehezkel Dror, *Public Policymaking Reexamined, ibid.*, pp. 327–356. For a survey of more recent relevant literature, see Yehezkel Dror, The Bibliographic Appendix in *Design for Policy Sciences* (N. Y.: American Elsevier 1971).

[i] For an extensive discussion of such weaknesses of applied social sciences and of analytical decision approaches, see Yehezkel Dror, "Systems Analysis and Applied Social Sciences," to be published in the proceedings of the Rutgers University and *Trans-Action* Magazine Conference on Public Policy and Social Science (Carpender Conference Center, Rutgers University, New Brunswick, N. J., Nov. 23–26, 1969), edited by Irving L. Horowitz.

I could go on adding additional items to the list of inadequacies of most contemporary efforts to build up policymaking knowledge. But I think the problem goes beyond a shorter or longer list of discrete weaknesses. The problem is not one of accidental omissions that can be easily corrected. Rather, I think that the overall lack of saliency of contemporary scientific endeavors to the improvement of policymaking reflects a basic discongruency between the paradigms of contemporary sciences in all their heterogeneity and the paradigms necessary for building up policymaking-relevant scientific knowledge.

To put this opinion into a positive form, it seems to me that in order to build up a science of policymaking, we need a new type of science based on a new set of paradigms.[j] Following the pioneering suggestion of Harold D. Lasswell,[k] I propose to call this new area of study, research, teaching, professional activity, and application "policy sciences"; but the name does not really matter.

As a matter of fact, policy sciences are at present in *status nascendi* and hopefully approach a taking-off stage. Among the signs of their emergence, let me mention the following:

1—The already mentioned proliferation of research and study of various policymaking issues within new and traditional disciplines. This testifies to widespread interest and serves to build up important, though disjointed, subcomponents of policy sciences.

2—The invention and development of new types of policy research organizations that, in effect, engage in the development and application of policy sciences. The Hudson Institute, the Urban Institute, parts of the Brookings Institution, the new Woodrow Wilson Foundation, the Institute for the Future, the Rand Corporation, and the New York-Rand Institute illustrate this trend in the United States.

3—The self-education of outstanding individual policy scientists who, thanks to personal multidisciplinary background, accidents of opportunity, and interest in application of scientific methods to acute problems, got into the pioneering of policy sciences and thus demonstrated the feasibility of policy sciences and its promises.

4—The recent establishment of new university programs devoted to policy

[j] My terminology follows Thomas S. Kuhn, *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press, 1962.

[k] The concept of "policy sciences" was first proposed in 1951 by Harold D. Lasswell, in Daniel Lerner and Harold D. Lasswell, eds., *The Policy Sciences: Recent Developments in Scope and Methods*, Stanford: Stanford University Press, 1951. For recent versions of Lasswell's views, see Harold D. Lasswell, "Policy Sciences" in *International Encyclopedia of Social Sciences*, Vol. 12, pp. 181–189, and Harold D. Lasswell, "The Emerging Conceptions of the Policy Sciences," *Policy Sciences*, Vol. 1, No. 1, 1970, pp. 3–14. The subject is extensively treated in a forthcoming book by Harold D. Lasswell, *A Preview of Policy Sciences* in Yehezkel Dror, *Ventures in Policy Sciences: Concepts and Applications* (N.Y.: American Elsevier, 1971) and in Yehezkel Dror, *Designs for Policy Sciences*, op. cit.

sciences, with or without use of that term. In the United States alone, more than ten such programs have been initiated during the last two or three years.[l]

5—The rapidly increasing number of conferences, books periodicals, "invisible colleges," and similar expressions of professional activity and interest devoted in effect to the advancement of policy sciences as a whole or of some of its major aspects.[m]

These are some of the signs of search, concern, experimentation, and interest that, I think, indicate the emergence of policy sciences. Nevertheless, at best, we are only in the first stages of the required scientific revolution, and there is no assurance that it will be successful in bringing forth a viable and significant new kind of science. The challenge may be beyond our intellectual abilities, charlatans may discredit the idea of policy sciences before it really gets started, political culture may inhibit the efforts, or the conservatism of "normal" scientists may choke it. Even if policy sciences do emerge as a new type of scientific endeavor, it is doubtful that one can predict now their future characteristics and implications. Therefore, the following exploration of the new paradigms of policy sciences and of their applied implications should be regarded as a normative forecast, directed at least as much at shaping the future as at foreseeing it.

Subject to this qualification, I think that preliminary examination of some of the unique paradigms of policy sciences, as I see them, will serve to illuminate both the current effort and the urgent need. It will also serve as a basis for examining some applied implications. As our analysis is a rough one, mistakes in some specifications do not matter. It is in the overall *Gestalt* of policy sciences that we are interested.

Some New Paradigms of Policy Sciences[n]

It seems to me that the main paradigmatic innovations to be required of and expected from policy sciences can be summed up as follows:

1—The main concern of policy sciences is with understanding and improvement of macrocontrol systems: that is, public policymaking systems. In addition to overall improvement-oriented study of such systems, main foci of policy sciences include, for example (a) policy analysis, which provides heuristic methods for identification of preferable policy alternatives, (b) alternative innovation, which deals with the invention of new designs and possibilities to be considered in policymaking, (c) master policies, which provide guidelines, postures, assumptions, strategies, and main guidelines to be followed by specific policies, (d) evaluation and feedback, including, for instance, social indicators, social experimentation, and organizational learning, and (e) improvement of the policymaking structure through redesign and novadesign of its organizational components, selection and training of its personnel, and reconstruction of its communication and information network. While the main test of policy sciences is better achievement of considered goals through more effective and efficient policies, policy sciences as such are, in the main, not directly concerned with the substantive contents of discreet policy problems (which should be dealt with by the relevant normal sciences), but rather with improved methods, knowledge, and systems for better policymaking.

2—Breakdown of traditional boundaries between disciplines, and especially between the various social sciences and the decision disciplines. Policy sciences must integrate knowledge from a variety of branches of knowledge and build it up into a supradiscipline focusing on public policymaking. In particular, policy science is based on a fusion between social sciences and analytical decision approaches. But it also absorbs many elements from decision theory, general systems theory, organization theory, operations research, strategic analysis, systems engineering, and similar modern areas of study. Physical and life sciences are also relied on, insofar as they are relevant.

3—Bridging of the usual dichotomy between "pure" and "applied" research. In policy sciences, integration between pure and applied research is achieved by acceptance of the improvement of public policymaking as its ultimate goal. As a result, the real world becomes a main laboratory of policy sciences, and the test of the most abstract theory is in its application (directly or indirectly) to problems of policymaking.

4—Acceptance of tacit knowledge and personal experience as important sources of knowledge, in addition to more conventional methods of research and study. Efforts to distill the tacit knowledge of policy practitioners and to involve high-quality policymakers as partners in building up policy sciences are among the important characteristics distinguishing between policy sciences and contemporary "normal" sciences.

5—Policy sciences share with normal sciences main involvement with instrumental-normative knowledge, in the sense of being directed at means and intermediate goals rather than absolute values. But policy sciences are sensitive to the difficulties of achieving "value-free sciences" and try to contribute to value choice by exploring value implications, value consistencies, value costs, and the behavioral foundations of value commitments. Also, parts of policy sciences are operative in invention of different "alternative futures," including their value contents. Furthermore, "organized creativity"—including value invention—constitutes important inputs into parts of policy sciences (such as policymaking-system novadesign and redesign, policy design, and policy analysis), and encouragement and stimulation of organized creativity is therefore a subject for policy sciences. As a result, policy sciences should make a breach in the tight wall separating contemporary sciences from ethics and philosophy of values and build up an operational theory of values (including

[l] The graduate university programs about which I happen to know include, in no particular order: The program in public policy at the John F. Kennedy School at Harvard University; the Doctoral Program in Policy Sciences at the State University of New York at Buffalo; the Graduate School of Public Affairs at the University of California, Berkeley; the Doctorate Program in Social Policy Planning, also at the University of California, Berkeley; the Graduate Program in Planning at the University of Puerto Rico; the Institute for Public Policy Studies at the University of Michigan; the School of Urban and Public Affairs at Carnegie-Mellon University; the Doctorate Program in Public Policy Analysis at the Fels Institute of Local and State Government at the University of Pennsylvania; the Program in Planning and Policy Sciences, also at the University of Pennsylvania. Also moving in the same direction seem to be the Lyndon B. Johnson School of Public Affairs at the University of Texas, a proposed Center for the Policy Sciences at Brown University, and a proposed new school at the University of Hawaii.

[m] To illustrate, let me mention some relevant recently founded periodicals: *Futures, Long-Range Planning, Policy Sciences, The Public Interest, Public Policy, Socio-Economic Planning Sciences,* and *Technological Forecasting.*

[n] This and the following section lean in part on Yehezkel Dror, "Prolegomenon to Policy Sciences," *Policy Sciences,* Vol. 1, No. 1, Spring 1970, pp. 135–140.

value morphology, taxonomy, measurement, etc., but not the substantive absolute norms themselves) as a part of policy sciences.

6—Policy sciences are very time-sensitive, regarding the present as a "bridge between the past and the future." Consequently, they reject the ahistoric approach of much of contemporary social sciences and analytical approaches. Instead, they emphasize historic developments on one hand and future dimensions on the other hand as central contexts for improved policymaking.[o]

7—Policy science does not accept the "take it or leave it" attitude of much of contemporary social sciences, neither does it regard petition signing and similar "direct action" involvements as a main form of policy science's contributions (in distinction to scientists acting as citizens) to better policymaking. Instead, it is committed to striving for increased utilization of policy sciences in actual policymaking and to preparation of professionals to serve in policy-sciences positions throughout the macrocontrol system (without letting this sense of mission interfere with a clinical and rational-analytical orientation to policy issues).

8—Policy science deals with the contribution of systematic knowledge and structured rationality to the design and operation of macrocontrol systems. But policy science clearly recognizes the important roles both of extrarational processes (such as creativity, "intuition," charisma, and value judgment) and of irrational processes (such as depth motivation). The search for ways to improve these processes for better policymaking is an integral part of policy sciences, including, for instance, possible policymaking implications of altered states of consciousness. (In other words, policy sciences faces the already mentioned paradoxical problem of how to improve extrarational and even irrational processes through rational means.)

Some Implications of Policy Sciences

Any policy science the *Gestalt* of which resembles the image conveyed by the proffered policy sciences paradigms will have far-reaching implications. Of relatively minor importance are various implications for the organization of science, its research, and its teaching. These include, for instance, transfer of some major research and teaching functions from universities to policy-research organizations; participation of experienced politicians, executives, and similar policy practitioners in scientific activities; novel teaching designs;[p] and new career patterns entailing transitions between abstract policy sciences research, long-range policy research, and policy analysis of pressing issues—accompanied by movement between universities, policy research organizations, and a variety of new roles in various branches of government and in public, quasi-public, and private organizations.

Those are implications of much importance for academia. But from an

[o] On the relations between future studies and policy sciences, see Yehezkel Dror, "A Policy Sciences View of Future Studies: Alternative Futures and Present Action," *Technological Forecasting and Social Change*, Vol. 2, No. 1 (Winter 1970), pp. 3–16.

[p] For an illustration, see Yehezkel Dror "Teaching of Policy Sciences: Design for a University Doctoral Program," *Social Science Information* Vol. IX, No. 2 (April 1970), pp. 101–127.

overall social point of view the critical significance of policy science is in basic changes that it brings about in the age-old dilemma of *scienta et potentia*, knowledge and power. These, in turn, have far-going implications for the exercise and structure of social power, that is, for politics.

The relevant unique feature of policy science is that it presumes to deal with the internal processes of policymaking and presumes to tell the policymakers how to arrive at decisions. This is a degree of penetration into the innermost processes of politics removed by a step-level function from the contributions of contemporary "normal" sciences to policymaking. Contemporary "normal" sciences supply inputs to be taken into account in policymaking and sometimes propose solutions as stipulated outputs of policymaking; but contemporary "normal" sciences do not open up the black box of how policy decisions are made and do not claim to develop scientific models for rewiring the box.[q]

In blunt language, the more policy science indeed does develop, the more the policymaking system should be redesigned to avail itself of policy sciences knowledge and the more politics should be reformed to permit full symbiosis between political power and policy sciences knowledge. The basic roles of elected politicians in a democratic society will not be impaired. Indeed, the critical functions of value judgment, interest presentation, consensus maintenance, and trans-scientific judgment not only will not be weakened but will be strengthened, thanks to clearer presentation of alternatives, better control of implementation, more reliable feedback, fuller explication of tacit theories, and similar contributions of policy analysis. But essential are policymaking arrangements that will assure that policy-science knowledge will be correctly appreciated and taken into account and that both its underutilization and its overutilization will be avoided.

Somewhat to concretize this general idea, let me present some implications for changes in the policymaking system that seem to result from initial work in policy sciences.[r] To provide variety in my illustrations, some are presented as a short enumeration while others, which are less technical, are discussed at some length:

1—Pervasive utilization of policy analysis for consideration of issues, exploration of alternatives, and clarification of goals.[s]

[q] Some exceptions are provided by political science and public administration, both classic and modern. But the relevant work in political sciences tends to suffer from one or more of the following characteristics, which make them inadequate surrogates for policy sciences: (1) mainly ideological orientation; or (2) mainly technical orientation, dealing with "administrative efficiency"; (3) focus on specific components of the policymaking system, without an overall systems view; (4) absence of empiric basis; or (5) absence of decision theory basis.

For discussions of administrative reforms that clearly bring out these and additional weaknesses of administrative reforms theory and reform practice alike, see: Ralph Braibanti, ed., *Politics and Administrative Development*, Durham, N. C.: Duke University Press, 1969; Gerald E. Caiden, *Administrative Reform*, Chicago: Aldine Publishing Company, 1969; and the still unique Dwight Waldo, *The Administrative State*, New York: The Ronald Press, 1948.

[r] For a detailed discussion of some of these recommendations and their policy sciences theoretic bases, see Yehezkel Dror, *Public Policymaking Reexamined*, op. cit., esp. Part V, pp. 217 ff.

[s] See Yehezkel Dror, *Design for Policy Sciences*, op. cit., chapter 9, 1969.

2—Encouragement of explicit policy strategy decisions, in distinction from discrete policy determinations. Explicit strategy decisions (including mixed strategies) are needed on the following issues, among others: degrees and locations of acceptable innovations in policies; extent of risk to be accepted in policies and choice between a maximax strategy or/and maximin strategy and/or min-avoidance strategy;[4] preferable mix between comprehensive policies, narrow-issue-oriented policies, and shock policies (which aim at breakthroughs accompanied by temporary disequilibration); and preferable mix between policies oriented toward concrete goals, toward a number of defined future options, and/or toward bulding up resources better to achieve as yet undefined goals in the future.

3—Encouragement of comprehensive master policies, in which discrete policy issues are considered within a broader context of basic goals, postures, and directives.[5]

4—Systematic evaluation of past policies to learn from them for the future. For instance, methods and institutions should be established every fixed period to provide an independent audit of the results of legislation.

5—Better consideration of the future. Special structures and processes should be designed to encourage better consideration of the future in contemporary policymaking.[6] This includes, for instance, dispersal of various kinds of "lookout" organizations, units, and staff throughout the policymaking system and utilization of alternative images of the future and scenarios in all policy considerations.

6—Search for methods and means to encourage creativity and invention in respect to policy issues. This may entail, for instance, no-strings-attached support to individuals and organizations engaging in adventurous thinking and "organized dreaming"; avoidance of their becoming committed to present policies and establishments; and opening channels of access for unconventional ideas to high-level policymakers and to the public at large. Creativity and invention may also be influenced within policymaking organizations by institutionally protecting innovative thinkers from organizational conformity pressures. Requiring careful study also are creativity-amplifying devices and chemicals and arrangements for their possible use in policymaking.

7—Establishment of a multiplicity of policy-research organizations to work on main policy issues. Some of these policy research organizations would work for the central Government, some for the legislature, and some for the public at large, diffusing their findings through the mass media of communications.

8—Development of extensive social experimentation designs and of institutions able to engage in social experimentation (including reconsideration of related ethical problems). It seems quite clear that social experimentation is essential for finding solutions to present and emerging social issues. For instance, new experimental cities may be needed to develop suitable habitations for the 100 million additional Americans expected by the year 2000. Careful social experimentation requires invention of new research designs and of new legal-political arrangements. Also important and very difficult is the requirement for a political and social climate in which careful research and experimentation on social institutions is encouraged. (To take a United States illustration: A change is needed in attitudes that expressed themselves, for instance, in the legislative prohibition of studies on the operation of juries.)

9—Institutional arrangements to encourage "heresy" and consideration of taboo policy issues, such as the possibilities of long-range advancement of humanity through genetic policies and of changes in such basic social institutions as the family.

10—Improvement of one-person-centered high-level decision making. Even though of very high and sometimes critical importance, one-person-centered high-level decision making is very neglected by both contemporary research and improvement attempts. This, in part, is due to difficulties of access, on one hand, and dependence of such decision making on the personal characteristics and tastes of the individual occupying the central position and on the other hand, the consequent difficulties in improving such situations. Thus, neglect of the study and improvement of one-person-centered high-level decision making is illustrated in the lack of suitable research methods, conceptual frameworks, and instrumental-normative models in contemporary normal sciences. With the help of the novel approaches of policy sciences, one-person-centered high-level decision making can be improved. Many conditions of better decision making can be satisfied by a variety of means, some of which may often fit the desires of any particular decision maker, e.g. information inputs, access of unconventional opinions, feedback from past decisions, and alternative predictions can be provided by different channels, staff structures, mechanical devices, and communication media. This multiplicity of useful arrangements provides sufficient elasticity to fit the needs, tastes, preferences, and idiosyncrasies of most, if not all, top decision makers.

11—Development of politicians. The idea of developing the qualifications of politicians is regarded as "taboo" in Western democratic societies. But this is not justified. The qualifications of politicians can be improved within the basic democratic tenets of free elections and must be improved so as to permit the required new symbiosis between power and knowledge. Thus, for instance, politicians need an appreciation of longer-range political, social, and technological trends, need capacities to determine policy strategies, and should be able to critically handle complex policy-analysis studies. One possible approach to the problem is to encourage entrance into politics of suitably quali-

[4] I use the term "min-avoidance" to refer to policies directed at avoiding the worst of all possible situations. One important advantage of such a strategy concerns support recruitment: it is often much easier to achieve agreement on ills to be avoided than on operational positive formulations of "good life" to be realized.

Some success in min-avoidance would constitute a significant improvement over reality. However simple this may sound, human capacities to approximate minimin are amazing. Still well worth reading in this connection is Walter B. Pitkin, *A Short Introduction to the History of Human Stupidity*, New York: Simon and Schuster, 1932. Recent policies around the world could provide a long second volume for such a history.

[5] President Nixon's First Annual Foreign Affairs Message, *United States Foreign Policy for the 1970s: A New Strategy for Peace*, well illustrates such an effort. It is relevant to observe that this innovation in comprehensive master policies is closely related to the existence of a new type of policymaking improvement-oriented policy analysis unit in the White House, namely, Dr. Kissinger's staff.

Preparation of similar master policies for, say, urban problems would require more than establishment of a parallel urban policy analysis unit in the White House. The basic-concept package and integrative framework have first to be developed. Among the urgent tasks awaiting policy sciences is work on overall policy-concept packages, on integrative problem mappings, and on issue taxonomies.

[6] The recently established National Goals Research Staff in the White House is an interesting step in this direction.

fied persons and to vary the rules of presentation of candidates to permit better judgment by the voter. Other, less radical proposals are to establish policy-sciences programs in schools where many future politicians study (such as law schools), and to grant to elected politicians (e.g. members of a state legislature) a sabbatical to be spent in self-developing activities, such as studying and writing. Suitable policy-sciences programs can be established at universities and at special centers for active politicians to spend their sabbaticals in a productive and attractive way.

12—Advancement of citizen participation in public policymaking.[w] Here, modern technology may be very helpful by providing tools for much better presentation of policy issues before the public (e.g. policy analyses of controversial issues on TV and citizen involvement through active participation in policy games through cable TV) and for more intense participation of the public in decision making (e.g. systematic opinion polling with the help of computer home consoles).

13—Education of adults for more active roles in public policymaking. I just mentioned the intensification of citizen participation in public policymaking as one of the possible policy sciences-recommended improvement. But in order for increasing citizen participation to constitute in fact an improvement, changes in the quality of that participation are needed. At the very least, more knowledge on policy problems, better understanding of interrelations between different issues and various resolutions, and fuller realization of longer-range consequences of different alternatives are needed. Also highly desirable are better value explication and sensitivity to value trade-offs, increased propensities to innovate, and capacities to face uncertainty.

The slogan of "enlightened citizen" as a requisite of democracy has been with us for too long to be taken seriously. Nevertheless, increasing demands for citizen participation based on both ideological reasons and functional needs do combine and make "citizen enlightenment" a hard necessity. Indeed, because of the growing complexity of policy issues, increased quality of citizen contributions to public policymaking is essential to preserve the present level of citizen participation in public policymaking. In other words, if the quality of citizen inputs into public policymaking remains as it is now, meritocracy may well become the only chance for survival. Therefore, building up the policy-contribution capacity of citizens is essential for the continuous viability of democracy.

This is the challenge facing adult education from the point of view of public policymaking improvement. To meet this challenge, radical novadesign of adult education is required.

To concretize, let me mention these main policy sciences-related directions of novadesign of adult education:

(a) Policy sciences must develop new formats for presenting and analyzing public issues in the mass media of communication in ways conducive to formation of informed individual opinions. For instance, policy issues should be presented in the form of policy-analysis networks, with clear alternatives, explicit sensitivity analysis, uncertainty explication, and assumption visibility.

[w] For elaboration of this and the next two points with specific reference to urban problems, see Yehezkel Dror, "Urban Metapolicy and Urban Education," *Educational Technology* (September 1970), pp. 18–21. Vol. X, N. Y.

Techniques are required for presentation of such programs on TV in ways to combine audiences appeal with improvement of citizen comprehensions of complex issues.

(b) Training tools that are simultaneously interesting and beneficial must be developed. Such tools include, for instance, cases, projects, policy games, and individual policy-exploration programs. In particular, policy games and individual policy-exploration programs are very promising. Based on computers and brought to each house through cable TV and home computer consoles, suitable games and policy exploration programs should be able to combine education for better policymaking with inputs into ongoing policymaking.[x]

(c) Incentives for participation in policy-oriented educational activities must be provided. It is to be hoped that increased opportunities to participate in public policymaking, together with availability of clearly relevant learning opportunities, will provide basic motivation. This may be the case all the more because of the possibility—illustrated by the proposed techniques—of combining the useful with the attractive. But additional incentives may be necessary. Competitive games and exercises may provide one set of incentives; public attention and dramatizaton may provide a second. If this is not successful, reservation of some special opportunities to participate in public policymaking (other than the basic rights of voting, expression of opinion, etc., reserved, of course, for all) for those who do undergo a set of learning activities might prove necessary in some circumstances in the longer run. But adoption of suitable programs in schools—to be discussed later—should make such distasteful distinctions unnecessary.

These are only some illustrations that do point out the possibility for redesign of education to serve, *inter alia*, the needs of increasing citizen participation in public policymaking. This is a problem in need of much research and creativity.

14—Preparation of children for future roles in public policymaking. On a more fundamental level, preparation for increased participation in public policymaking must take place before maturation. The best location to prepare the citizen for increased policymaking roles is in school, when the necessary knowledge and capacities should be developed as a basic part of the equipment needed by every citizen in a modern, urban, democratic society.

The necessary knowledge and capacities to be conveyed and developed at school do include, among others, some knowledge and understanding of the social system and of social dynamics; a feel for alternative social futures; abilities to handle uncertainty and probabilities; basic skills in logic and semantics; understanding of the elements of policy analysis and capacity to handle problems with the help of policy-analysis networks; tolerance of ambiguity; appreciation of main concepts of social sciences, economics, and decision theory and their application to policy issues; and ability to search for information on new problems and issues and absorb that information within one's frame of appreciation.

This formidable list may look prohibitive, unless we bear in mind that no technical skills and professional knowledge are aimed at. Some familiarity with fundamental concepts, some appreciation of their use and—most im-

[x] E.g. see Stuart Umpleby, "Citizen Sampling Simulation: A Method for Involving the Public in Social Planning," Paper presented at the International Future Research Conference, Kyoto, Japan, April 10–16, 1970.

portant of all—some skill in application of the knowledge and concepts to concrete issues as a main mode for making up one's mind are the only aims.

Even so, this is an ambitious program, which can be approximated only through far-reaching changes in school teaching. Much of the required knowledge and capacity should be developed through new approaches and novel teaching methods in traditional subjects. Thus, the study of history should include the history of policy issues, should be problem-oriented, and should be supplemented by treatment of alternative futures. To add another illustration: mathematics should be taught as a problem-solving approach, with emphasis on probability theory, Boolean algebra, and theory of games. Some new subjects also have to be added, devoted explicitly to policy problems and policy analyses. In the new subjects and in the new contents of the traditional subjects, new teaching methods will play a major role. Such new teaching methods will include, for instance, gaming, computer interaction, and internships. Existing methods, such as projects and essays, can also be very useful, if suitably adjusted.

All this depends on the development of policy-sciences knowledge, which can serve as a basis for suitable teaching material and teaching methods. Here we meet another innovative facet of policy sciences: it should not constitute esoteric knowledge monopolized by an initiated few; instead, conscious and intense efforts must be made to transform at least the basics of policy-sciences knowledge into forms that can be widely communicated to different policymaking actors, to the interested broad public, and even to schoolchildren.

Lest the impression created by these illustrative policy-sciences implications for redesign of policymaking is that most of the burden of change lies on politics, the public, and education, let me add a word on implications for the scientific community, which go beyond the earlier-mentioned reorganization of research, teaching, and career patterns.

The emergence of policy sciences leads not only to many requirements for repatterning politics, education, etc., but also for repatterning the contributions of scientists to policymaking. At present, many of the pronouncements of scientists on policy issues suffer from serious defects, as can easily be illustrated from the debates on such issues as pollution, the nuclear test ban,[y] and the ABM.[z] These defects are related to failure to distinguish—first of all, for oneself, and then in one's pronouncements—between highly reliable scientific facts within the professional competence of the actor, doubtful scientific facts within the area of competence of the actor, issues that belong to science but are not within the competence of the actor, and issues that are outside the domain of science, such as judgment of values to be pursued and of value priorities, judgment in risks to be taken, and judgment on time preferences and metaphysical assumptions.

As a result of the failure to make these distinctions, recommendations are often presented "in the name of science" that, in fact, are based on assumptions and preferences in large part outside the domain of competence of the actor.

Even with the present very limited policy-sciences knowledge, this state of affairs is not only regrettable but inexcusable: knowledge in policy analysis already available permits presentation of recommendations by scientists in formats that clearly distinguish between the different bases of their recommendations. Such formats would enable those entitled to it—whether the elected politicians or the public at large—to exercise their judgment in respect to those issues not included within the area of competence of the recommending scientist; therefore they should be widely used even now. When policy sciences are more developed, the demand on scientists to be self-sophisticated and self-restrained in their contributions to policymaking becomes more than a recommendation; it becomes, I think, a moral absolute imperative, deviation from which may well destroy democracy, science, or both. Thus, the emergence of policy sciences will be accompanied by very strict and, in some respects, restrictive, demands on scientists, not less so and perhaps even more so than on politicians and other actors in the public policymaking system.[aa]

[y] Cf. Robert Gilpin, *American Scientists and Nuclear Weapons Policy* (Princeton, N.J.: Princeton University Press, 1962) and Robert A. Levine, *The Arms Debate* (Cambridge, Mass.: Harvard University Press, 1963).

[z] See Yehezkel Dror, *Energy States: A Counterconventional Strategic Problem* (Boston: Heath & Co.), 1971 (in press), chapter 1.

Conclusion

Policy sciences holds forth the hope of improving the most backward of all human institutions and habits—policymaking and decision making. It constitutes a major attempt to assert and achieve a central role for rationality and intellectualism in human affairs and to increase by jumps the capacity of humanity to direct its futures. Important first steps to build up policy sciences are being attempted now. There is no assurance that these steps will lead anywhere and that the endeavor to build up policy sciences will succeed. But the expected benefits of policy sciences, and—even more—the gloomy results of failure to advance policy sciences, make this endeavor one of the more critical challenges ever faced by science. It is also one of the most difficult challenges because of the intrinsic difficulties of the subject, because of the needed revolution in scientific paradigms, and because of the far-going and in many respects radical implications. Therefore, policy sciences needs and deserves all the help it can get, including first of all strong support and intense personal commitment from the scientific community.

[aa] Especially vexing are the moral issues facing policy scientists. While all knowledge can be used for "good" and for "bad," the high potentials of policy sciences require special safeguards to reduce the probabilities of misuse. This problem is beyond the confines of this paper, but I want explicitly to point it out.

ECONOMIC AND SOCIAL STRATEGIES; EXPANSION OF SCIENTIFIC KNOWLEDGE

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Premise: The prospects for mankind largely depend on the expansion of scientific knowledge and of its technological application.

Moreover, the effects of scientific knowledge are, for the most part, the technological instruments that have transformed the conditions and characteristics of man's way of life and of his relationships. New means of communication and new tools have made the world smaller, and the growing interdependence among the world's nations has unified man's destiny and tends to render his problems common.

Some other developments in scientific knowledge are less apparent to the public view; nevertheless, they are extremely imporant: the emancipation of the human mind from superstitions, which are rather frequently the cause of primitive customs and of obsessive fears; the elimination or the erosion of the intellectual foundations of social, cultural, and moral principles and dogmas, with the consequent reduction of the props that irrational traditions provide for many injustices; the continuously diffuse development of an intellectual and ethical attitude of critical revision of the beliefs and statements that derive from tradition or from authority or, in any case, are with us today; and, essentially, the introduction, into subject matter from which critical and systematic thought was once excluded, of logical methods to examine, on the basis of reliable data, many questions of actual fact or practical choice.

Nevertheless, some effects (of a logical, ethical, and practical nature) of scientific and technological progress give rise to various reservations and, for the future, to serious anxieties.

We hint here at the tendency to suggest that a goal of scientific research is to define criteria of human progress. We also refer to the "scientific" tendencies that assert the self-coherent logics of efficiency, productivity, and power as necessary and fruitful—tendencies, in effect, directed to conceal attitudes of *particularisms* and of sterile privileges.

Such aberrations, that is, notions of the possibility of scientific "truths" outside the scope of science and, in addition, outside the scope of their general validity for social goals, with their corollaries of varied and particular ideologies, have already caused several contradictions in the orderings and relations of men and in the purposes of technological and applied research.

Furthermore, many recent technological advances, and many of the more revolutionary advances that must soon occur, are such that problems of evaluation, decision, and behavior—problems for which we cannot really know either the terms or the solutions—will be posed for the future.

We know with certainly only, that, in the sense of the tendencies or ideologies that we have indicated as "aberrant," humanity must face irreversible destruction of those values that we maintain are essential.

The expansion of scientific and technological knowledge and technical

progress constitute, even with their actual and possible defects, a presumably endless element in human affairs. Such expansion forms one, but only one, of man's means or instruments in the struggle to improve the human condition.

We are compelled, at this point in history, to examine what men must do so that scientific and technological expansion will operate for the progress of humanity—that is, to consider what men must not do with scientific knowledge, the limits that this knowledge can provide, and the criteria for its major developments in the most human sense.

Structures and Intrinsic Dynamics of the Expansion of Scientific and Technological Knowledge

The expansion of scientific knowledge, which is at the same time, tradition and creation, emerges from what is already known. And to be able to learn, or to apply, or to repeat an application we need specific preparations. At the heart of scientific and technological expansion is, in effect, man's potential and, indeed, one function of fundamental research is precisely the formation—the development, the encouragement—of the human potential.

The growing specialization of scientific and technological knowledge in specific matters and fields corresponds to objective reality and necessities; these are naturally reflected in the preparation of the human potential, which must, of course, be highly skilled.

However, reality and problems are interdependent; for this reason, the activities and programs of scientific and technological expansion require the organized participation of many kinds of skilled personnel. More specifically, we must realize that structures and needs of research are shifting their emphasis toward the applications of science, toward growing refinements, integrations, and increases of knowledge from quantitative levels to qualitative levels. For example, mathematicians are enlarging their field to include physical problems, physicists are more and more oriented toward chemical and biological problems, and chemists are concerned with the treatment, on the molecular level, of biological, agricultural, and electronic problems.

A second category of means for scientific and technological expansion is that which may be summed up as the totality of "mass media." This category is a varied complex: positive and negative data, publications, memoirs, correspondence, etc. Furthermore, as has always been the case, goods often constitute the most efficient vehicle for the diffusion of an innovation.

Based on a fundamental formula—that knowledge depends on knowledge—we may observe that scientific and technological knowledge may already be symbolized as a single, enormous patrimony vital to all scientific and technological expansion. Unlike all other resources at man's disposal, this patrimony is capable of indefinite utilization without limits of space or time. We may draw on this patrimony without reducing it, just as we may increase it by adding to it every new increment of knowledge.

New cognitive acquisitions can allow either a simple quantitative increment, or the elimination, because of obsolescence, of some of its components—components that may appear useless because of either the fallacy of a principle or a new technological expedient that is more efficient than earlier expedients.

All this patrimony is, intrinsically and potentially, known or knowable to anyone, except for military and industrial secrets (secrets of manufacturing

processes, knowhow, etc.). It is available to anyone for any aim, whether intellectual or practical. We must remember, however, that while private patents allow exclusive rights for practical use, on the information level, these patents have an educational function.

What we have said so far means that, for every kind of scientific and technological expansion, every valid system of documentation assumes an essential importance and weight. The systems must be rapid and complete in order to permit us to understand the results attained and to utilize the most advanced methodologies and instrumentation in the various fields—all for the purpose not only of avoiding a search for objectives already gained but also of facilitating independent research. Such research will have to be conducted under conditions of an efficiency that is far above the workaday and frequently unbalanced level that often characterizes research activity in normally developed countries. The establishment of such information-gathering and dissemination systems would have the effect of enlarging and examining closely the field of knowledge and of giving broad and sound bases to creative imagination.

No wonder, therefore, that, for the future, automatic systems for the collection, storage, retrieval, and availability of data assume a determining importance even though, in spite of the great advances achieved in this field, the degree of efficiency, until now, has not been of a universally high order.

As a prospect for the future, we must keep in mind, besides the diffusion of scientific and technological knowledge, the trends that are beneficial for the progress of that knowledge as well.

In regard to diffusion, it is obvious that, for every milieu, diffusion must be considered a function either of the specific scientific potential, above all human potential, or of the importance that is attributed, in that milieu, to such an expansion for the attainment of specific objectives. The fraction of the resources that will be assigned to reach these goals will be determined in harmony with their importance.

But we must keep in mind a number of conditions that make the previously discussed needs and problems even more complicated and difficult. In this historical period, people tend to produce in greater volume than they read or think. The efforts made in scientific research do not necessarily lead to important changes; many efforts are intrinsically more likely to increase the volume of scientific literature than to open truly new paths.

Sometimes, especially in the developed countries, people tend to indulge in "research in pursuit" (i.e., unoriginal research) that results only in adding a trifle to what is already known, instead of singling out and pursuing new ideas; in other words, people do not think deeply enough before initiating a research project that might have prospects of originality.

All of the foregoing is a consequence of an external conditioning of research activities, a consequence that is the result of the generalized criteria of selection. Because of these criteria, in order to obtain desired promotions in university careers, there is a continuous clash between the quantity and the quality of publications; results that are not always rational derive from this situation.

Consequently, we must revise the systems of judging scientific production, giving more weight to basic knowledge and to the critical examination of research already completed by others; this will, in turn, encourage new research, but only after competent debate and thorough and thoughtful examination of the scientific validity of the hypotheses about previous and current work and the objective possibility of a useful and timely addition to the scientific com-

petition, which presupposes adequate structures as well as massive concentration of the means of research. The primary effort must be to know how much has been done; only on this basis will new research be possible.

The subject matter of these trends, which we have to assign to scientific research directed toward goals that are more or less near and immediate, assumes, in addition, a particular shape. Directions and objectives for such trends are determined on the basis of particular value systems and corresponding goals and priorities.

Expansion of Scientific and Technological Knowledge Within the Framework of Various Countries

We have already mentioned essential structures, paths, and causes of scientific and technological expansion based on a simplified model that does not, in fact, include all kinds of relations among various countries. It would be appropriate now to consider the principal occurrences of such relations as well.

Access to the international patrimony of knowledge, in reality, presupposes proper international relations that, for the most part, require the concurrence of other countries. There are a variety of imaginable complications that could develop to the detriment of functionality. Moreover, the specific interests of the various countries in regard to scientific and technological expansion act in such a way that the interest in relative progress, which is particularly advantageous to the individual country, prevails in that country over the general interest in the essential goal of science, the progress of humanity.

Such a prevalence of specific interests implies that:

—Any country in a position to control a definite part of the international patrimony of the scientific and technological knowledge could limit or prevent foreign access to that part in accord with its particular political and military or competitive interests;

—Any country may act competitively, even in regard to important factors for scientific and technological expansion; such factors may be found outside the particular nation's borders also. (The main, but not the only, example is the well-known phenomenon of the "brain drain");

—In particular, the operative departments of every country (industry, finance, agriculture, etc.), in providing for their own needs in relation to scientific and technological expansion, are conditioned and limited by relations of diverse kinds between the various countries.

For every country, the demand for the adequate formation of a scientific community necessary for all phases and directions of scientific and technological expansion, which corresponds to the country's needs, becomes more and more rigid.

On the national level, this encourages the greatest development of fundamental research activities, which, in turn, lead to development of the necessary staff for scientific and technological expansion and/or to the adaptation of technological innovations of other countries to local necessities, and for further internal technological innovations.

Equally basic is the necessity for the most efficient systems of documenta-

tion and for scientific and technological information; such systems must be adequately connected to analogous foreign systems and centers.

Based on the convergences of the common and/or complementary interests of two or more countries in relation to scientific and technological expansion, agreements for collaboration and international cooperation, by means of common research programs, exchanges of personnel and data, etc., are possible and desirable. The already mentioned *particularisms* tend to complicate international collaboration (one remembers, for example, the slogan "Internationalize the costs and nationalize the results") and to limit the possibility and the efficiency of that collaboration.

Despite the many barriers, the fundamental community of interest in advancement gives rise to many kinds of effective international cooperation in research, some of which are more or less noticeable and formalized.

Because basic science cannot be restricted within territorial, linguistic, religious, and racial bounds, young scholars will always have a liberal preparation and approach, whether in an international or an interdisciplinary sense. And here a question arises, that of the "brain drain." In effect, in scientific research no country should—indeed, no country can—isolate itself, especially in regard to the training of her young people, even at the cost of some "drain."

On this subject, apart from considerations of the pernicious and by now antihistorical criteria of *particularism* in scientific and technological matters, we must closely examine some considerations.

If a foreigner works, for example, in a U.S. laboratory and discovers something, the result is named after him and the prestige accrues to his native country. The discovery is the property of all mankind, however, and the principle of the universality of science remains valid. But, people say, does not the fact that a scholar works and produces abroad represent a "loss" for his native country? It is, in the first place, difficult to demonstrate that in his native country he would have been able to accomplish as much as he achieved abroad, and, in addition, the contribution of the scientific environment of the host country is not easy to appraise.

Instead, the problem arises concerning what kind of conditions we must create, particularly in smaller countries, to enable every individual's faculties and abilities to operate at their best and, consequently, to exploit the greatest number of talents. The problem does not present itself in the nonexperimental sciences, but it becomes acutely evident in the experimental sciences.

The first condition that we must achieve is international cooperation in research. This cooperation must be accomplished by creating and placing at the disposal of all countries such laboratories of the more advanced countries as the National Institute of Health, or of communities of nations, such as CERN (the European Council for Nuclear Research). These laboratories must be open to scholars from any nation who have prepared their studies with preliminary work in their own countries, perhaps in laboratories that are specialized and/or smaller. In other words, such scholars should alternate a period of classes in the universities of their own countries with periods of research in great laboratories throughout the world.

In conclusion, in order to reconcile the diffusion of science with its progress, we must improve the possibilities of exchange visits of scholars—in particular, of those from less fortunate areas. They should be able to make use of efficient information systems on the widest possible scale. In addition, they should be able to divide their time into two parts: the first dedicated to research

in major laboratories provided with all the equipment and facilities for significant and effective activity, the second devoted to the teaching to be carried out in the universities of their own countries, debating during special seminars the results of research and providing young students with the possibility of learning new methodologies and techniques, of attempting new paths, and of proving the validity of a new idea only after a long and thoughtful discussion.

The first overcoming of *particularisms* may be attained through a harmonic system of consistent cooperation among various countries in which each scholar participates in the advancement of knowledge according to his possibilities. Great science is possible for great countries; the other countries are interested in following the developments of science, participating independently in the extension of these developments on the level of "small science," and providing for the diffusion and application of such developments. The system is such that it reconciles in every country the exigencies of development in the various sciences with the possibility of their efficient utilization in the activities of research.

Diffusion of Scientific and Technological Knowledge

The level of *particularisms*, by which the contributions and participations are conducted in the various countries is evidently a handicap for scientific and technological expansion. For every country, in fact, the limitations on scientific and technological expansion are a handicap subsequently made worse by handicaps that each country imposes on other countries.

Directions for the Progress of Scientific and Technological Knowledge

The importance of scientific and technological knowledge for man's growth and development carries with it a requirement for the greatest diffusion of scientific and technological knowledge in every direction. Today, while principles and values of the past are more and more often in crisis because of scientific and technological advances and their implications, the problem of determining the lines of future research in order to maintain such progress is constantly growing more difficult. Nevertheless, such guides are indispensable for the orientation of technological and finalized research.

Problems of valuation, decision, and behavior—new and, moreover, relative to conditions that are also unknown—are overriding.

It would, of course, be possible to decide what will be desirable in the future if that future and its values could be known. Today we know only, although we know it with certainty, that the future of humanity depends on the course that its ideologies will take; this course will decide whether the irreversible destruction of the values we consider essential today will be averted.

And we know that all the claims to determine, through the scientific method, the trends of the future are, to the best of our knowledge, without meaning and, indeed, "aberrant." The values and the corresponding norms are not derivable from science, whose developments, on the contrary, are oriented precisely to values necessarily external and foreign to scientific research. In effect, such claims and, in particular, the "scientific" trends toward affirming the self-coherent logic of efficiency, productivity, and power as necessary and

fruitful are only a mask to cover those orientations and definite interests of which we are more or less conscious and able to single out.

Today we are confined to unfruitful inadmissible trends, criteria, or behavior *particularistcally* directed to a specific advantage (or to privileges interpreted as advantages that have an importance and a base only in other advantages). When the corresponding losses to other people are a matter of indifference, this, on the level of human solidarity, must be considered an unnecessary contradiction. Here lies the greatest problem and the greatest menace to the world.

The specific trends of scientific and technological expansion on the national level—in harmony, that is, with definite, specific systems of values, interests, and objectives—do not present any particular international importance.

Naturally, on the national level, the basic problems of the new and future technologies are reflected in man's condition. Such advancement, at hand or anticipated, must be considered, however, on a broad scale that ignores the particular situations of individual countries. On such a scale, it becomes evident that, on the basis of the various possible directions, much more is at stake than the survival of mankind. The preservation of his identity is in question, considering that man as a species is capable of assuming features that would make it unrecognizable to us. All this, which has always been the essential problem of progress, has become today, given the scientific and technological advancement and their rhythm, a definite dilemma for humanity.

The use of many technologies has become such that enormously important and irreversible consequences and repercussions are possible, consequences and repercussions to be debited either to the biosphere or to human relations and values. Many techniques, of a wide and growing diffusion, already cause deteriorations to the biopshere that are either intrinsically inevitable or ascribable to insufficient care of the environment; such deteriorations can upset the equilibria of the biological ecosystems.

On the level of human relations and values, the new situations and possibilities give rise to losses and dangers of extreme importance. The relations and the equilibria among nations are becoming more and more precarious, intense, and unbalanced.

The conditions of life and work, which, on the whole, have greatly improved in comparison with the most recent past, are in contrast with the progressive rarefaction of human relations and with the increasing impersonality of authority and institution, of the more and more anonymous work of the individual, and of man's growing personal, domestic, social, and political alienation. Science is a great instrument for man, but it is necessary that it be directed and applied to *human progress*.

Desirable General Criteria for Scientific and Technological Expansion

The directions in which scientific and technological expansion must be oriented will not be able to remain permanently *particularistic* in a world that is rapidly becomng smaller and more integrated. As such, particular interests will have to give rise to increasingly general interests, that is, on larger bases in matter and space. Conversely, in the same way in which scientific and technological expansion must and can proceed in the long run, occurrences of interests and *particularistic* criteria, which in different quantities and ways actually limit, condition, and direct the expansion, must be reduced.

Since the world is proceeding toward the interdependence of all men, the exigencies of human solidarity will tend, in fact, to be accentuated and to become dominant. Every man has and must be able to have his own personal beliefs and preferences. Science does not give, nor can it give, knowledge or instruments to its cultivators to decide—as scientists—what is good, right, useful, and appropriate for humanity in general and what decisions and behavior science will choose for its destiny.

THE TIMETABLE PROJECT

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The major problems and crises that human society now faces are not intrinsically new in our historical experience. Human development is a continuous record of the struggle against hunger, disease, war, and ignorance.

The present gravity and critical nature of these familiar aspects of the human condition is their expanded dimension. Their vastly increased scale and magnitude has been compounded, paradoxically, by those successful advances in the sciences and technologies that are the major means of combating them. By making man more secure against hunger and disease, we have added astronomically to the numbers of men: by shrinking the physical distance between peoples, we have increased the critical interdependence of all human societies; by communicating the material possibilities of a better life, we have enormously increased the expectations and demands of all peoples to share in our accumulated wealth and knowledge: and by the prodigal exploitation of our physical resources we have produced grave imbalances in our life-sustaining natural environment.

At the time, then, when we suddenly possess the developed skills and resources with which to solve many of our major human problems, they have, in turn, become seemingly intractable; and the recurring crises that accompany delays in providing solutions lead to frustration and conflict in major sectors of society. Disillusionment with rational means is encouraged, and an antiscientific and antitechnological bias begins to affect even the allocation of resources to those directions in which problem solutions might best be sought. This situation has been further obscured by the many conflicting ideas, plans, and programs for solution of major problems at the local and world level; such "solutions" often pay little regard to the actual, or potential, realities and limitations of the physical and human resources currently available to us.

Both the seeming "intractability' of the problems themselves and mounting public pressures for more immediate solutions arise, in part, from *the lack of a coherent and integrated assessment* of the resources, facilities, and time that may be required for even minimal solutions to many of our problems. Some problems could be solved tomorrow by legislative fiat. Others may take one year, five, ten, or twenty years, to reduce to less critical dimensions; and there are, obviously, several problems in human society that it may not be possible to solve, or even mitigate, in less than two or three generations. It is also increasingly evident that many problems approaching critical magnitude at various local national levels, e.g. population, health, education, environmental deterioration, etc., can no longer be solved even on national terms.

In similar fashion, the scale of many of our global technological systems, e.g. production, distribution, transportation, and communications, has gone

beyond the capacities of any single nation or group of nations to sustain and wholly operate. They require, and are dependent on, the resource range of the entire earth for the metals and materials of which they are built and the energies to run them—in which no single nation is now self-sufficient. The whole planetary "life-support system" is also increasingly dependent on the global interchange not only of physical resources and finished products but of the "knowledge pool"—research, development, technical and managerial expertise—and the highly trained personnel who sustain and expand this.

The scale and range of our technological intrusions into the planetary biosphere is now such that all large scale technoindustrial undertakings need, increasingly, to be gauged in terms of their long-range consequences and implications for the global community. In these combined senses, and at this scale, there are few wholly "local" problems that may be left entirely to the short-range "economic" expediency or temporal ideological preference of some exclusively national concerns or narrow self-interest groups.

The "problem of problems," therefore, lies within this realm: initiation of a series of authoritative and comprehensive reviews of major problem areas and their *interdependent* aspects, together with a sober evaluation of the resources, facilities, and priorities that set the *time* and *scale* of their possible solutions within the existing and projected state of our knowledge. From these reviews and evaluations would also emerge a long-range predictive model of the *"crisis-points range"* within which various interrelated world problems may reach dangerous proportions in the near future.

Such a task, though seemingly overambitious and beyond the scope of our currently organized national and international scientific programs, is now most urgent. Whether it *may* be feasible or not within the present state of our knowledge and our capacity to organize and apply that knowledge on such a massive scale, it is essential that we begin now. U.N. Secretary General U Thant has, indeed, suggested that our effective margin for engaging in such cooperative global actions is limited to the next 10 years—if we are to survive our present dilemmas:

> I do not wish to seem overdramatic, but I can conclude from the information that is available to me as Secretary General that the Membership of the United Nations has perhaps ten years left in which to subordinate their ancient quarrels and launch a global partnership to curb the arms race, to improve the human condition, to defuse the population explosion and to supply the required momentum to development efforts. If such a global partnership is not forged within the next decade, then I very much fear that the problems I have mentioned will have reached such staggering proportions that they will be beyond our capacity to control.[1]

The highly critical nature of our current transitional period is such that supportive research programs towards such global action should be given the highest priority by the international scientific community. This is strongly implied by the theme of this Conference and volume, *"Environment and Society in Transition,"* and might be considered as one of the central study and research foci for the development of the World University, which is also being discussed here.

Research and documentation for the organization of such a collaborative global network for the study and solution of world problems was carried out during the "World Design Science Decade" activity,[2] by R. Buckminster Fuller and myself, during the period from 1961 to 1968. This work focused on the

We should, of course, emphasize the wholly denotative convenience of labelling different parts of what is essentially a dynamic whole. When we deal with human activities, their complexity tends to force the use of simplistic models that can be fitted into some neat disciplinary forms. This can become dangerously misleading if we then assume that such problems can be solved within the artificial divisions set up for intellectual convenience. No social problem of small or large scale—and all human problems are axiomatically social—can be solved within the terms of any one discipline.

A wholly technological solution, however logical and seemingly efficient, may fail by overlooking some elementary sociocultural requirements. Conversely, solutions conceived solely in socioeconomic terms may fail through lack of adequate technological considerations. Also, the lack of a systemic whole-system approach to such problems may solve one problem—only to increase the critical range of another. Many of our crucial national and international problems have been caused by short-range and expedient economic and technological decisions taken with little or no regard for their longer-range deleterious effects on man and his environment. These points may seem obvious, but many of our current dilemmas arise from piecemeal and unsystematic approaches to the satisfaction of human needs and emergency solutions of human problems in our recent past.

Major world problems themselves[5] derive specifically from accelerated changes in the past century, when man approached an historical watershed comparable only to the earlier agricultural revolution. In terms of problem definition and priorities, the continued disparities between the so-called advanced nations and the lesser-developed ones may be viewed as the gravest threat to the global community. The explosive rises in population, the pressures on food, lands, and other resources, the scale of wastage, disorganization, and pestilence now accompanying our "local" wars are also linked in due measure to the revolutions in human expectations that now circle the globe.

This disparity between *have* and *have not* peoples may also be defined as part of a growing ecological imbalance in which the hyperactive advanced economics extract more, produce and consume more, and produce more waste, than the lesser-developed; and because of the increased dependence of the more advanced countries on raw materials from the lesser-developed countries, the former now exist in a directly parasitic relationship.

In terms of energy use, the more fortunate individual in the industrial countries consumes more than 50 times that of his counterpart in the poorer regions—and contributes in due measure much more than 50 times the by-product pollutants now critically affecting the global environ systems.

Overall, the advanced countries in the past decade consumed 77 percent of all the coal, 81 percent of the petroleum, and 95 percent of the natural gas for less than one quarter of the world's population; one nation alone, the United States, used one-third of the world's total industrial energy and consumed approximately 40 per cent of the world's output of raw materials.

In round terms, approximately 20 percent of the world's population currently enjoys 80 percent of the world's income and uses more than half of all the earth's resources, producing a concomitant balance of the biospheric pollutants that have become critically apparent in the past period.

This gap between rich and poor has other salient features that make it one of the most critical problems facing man in the next decade. When treated in terms of population and food, the widening gap has even more threatening

connotations. Present world population totals roughly 3.5 billion, and the current rate of increase about 1.8 percent per year will double world population in just 30 years, i.e., an agreed median estimate for 6 billion people by the year 2000. More than 80 percent of the current increase of population will be in those world regions that now have inadequate food supplies: Asia, Africa, and Latin America.

So the range of crisis points in terms of the population explosion alone is that not only does this doubling within one generation mean not only a necessary doubling of food supply but, if other material standards are to be achieved as well, it will require a doubling, and tripling, of housing, of city sizes, highways, consumer goods, etc., with their equivalent expansion of industrial materials extraction, production, and distribution, which, in turn, will necessitate more than tripling the energy consumption of the various fuels—and so on! In terms of *current* socioeconomic organization, the byproduct pollution and deterioration of the world environment might be near catastrophe.

Though much attention is given to closing the gap between rich and poor nations in traditional terms, through foreign aid, favorable trade balances, etc., it is rather sobering to consider more realistically what this means in material-resource-usage terms. To bring the total world population up to an advanced standard of Western material consumption would require, for example, more than five times the present world production of metals and minerals, which is far more than we can attain with current levels of materials and energy-conversion capacities.

Using one example—extending full-scale electrification to the lesser developed nations—we may note that the average use of copper in the industrialized nations is approximately 120 pounds per capita. The increase of even one pound per capita consumption for full-scale world electrification would require a 36 percent increase in world copper production.

In terms of the energy required for such living standard increase, we may underline that in dealing with higher metals extraction and use from increasingly lower-grade ores, the energy required for this alone would be overwhelming, i.e.,

> The conclusion to be drawn is that 5 billion persons living at present U.S. standards would require 25 times as much energy as the U.S. does today . . . (and) at 25 times the present U.S. consumption of coal, oil, and gas the human race would burn up the earth's estimated reserves of fossil fuels not in a matter of centuries, but in a few decades.[6]

Clearly we face many rigorous limitations on closing the gap between the rich and poor nations. Given our developing scientific and technological capabilities, it is possible, but the approaches must be examined more realistically than in terms of pious hope and traditional practices. Such gap closing is only one facet of the world problem. Even when we refer to the so-called *advanced* nations as enjoying higher standards of living, the quality of life itself is in question where such societies are already faced with severe dislocation, deterioration, and obsolescence in critical areas of their socioeconomic and political structures. Many of their internal institutions are archaic, strained toward breakdown, and their physical environments are still suffering from the backlash of the intial developmental phases of unrestrained industrial exploitation.

And, although we refer glibly to advanced scientific and technological

societies, not one of these yet has approached the beginnings of what might be termed a "scientific" society, i.e., one whose motivations, goals, and orientations are congruent with and permeated with the scientific outlook in the larger sense.

Returning more explicitly to the Timetable project, I would emphasize that such studies should not be confined within traditional disciplinary perspectives or within conventional "single-track" planning programs. The scale and range of problems the project is intended to confront, problems that are highly characteristic of the period itself, have a hitherto unknown degree of complexity. It will require the development of a new perspective and approach to the planning function in itself, i.e., "planning which cuts across a multitude of dimensions inherent in such a system—in particular, social, economic, political, technological, psychological and anthropological dimensions—has become known as *integrative planning*. Integrative planning is, above all, planning in terms of the quality of life." [7]

In light of the demand for relevance in the university structure and for a deeper commitment to problem-focused educational programs, this type of project may serve ideally as a nucleus for reorienting various aspects of university training. The aims of the project itself and the cross-disciplinary work that it will entail by both faculty and students should give a renewed sense of social purpose and of a deeper long-range involvement and commitment to the larger society.

Obviously, as framed in this brief paper, such a project could occupy a great number of professional experts for a long time. Its more pragmatic implementation in combination with the educational process itself may be the most efficacious way to begin and to take direct, gainful advantage of:

(1) A. The direct experience in problem-oriented education that would be derived from involvement in such a study by both graduate and undergraduate students in the university.

B. The postgraduate interdisciplinary work it may afford to a smaller number of those professionals in various fields—who would constitute the core staff.

C. The individual and collective expertise and experience available through a distinguished advisory board that would also assist in, and guide, the project, and through the collaborative involvement of a number of key institutes and organizations, both in the U.S.A. and abroad.

This initial pilot phase will occupy the first two years of the study. At the conclusion of this period its findings may then be assessed for the feasibility of continuing the study in greater detail and range, via a collaborative network of other centers and organizations on a larger national and international basis.

(2) A. *Relevance to "Social Navigation"*

Aspects of specific social and educational relevance.

(a) General social awareness and understanding of the problems accompanying the accelerated changes in the past century has not kept pace with the changes themselves. Attention has been most easily focused on the more newsworthy aspects of local tensions and societal crises that are, usually, the surface manifestations of larger problems rather than prime causal agencies. "Literacy" concerning the purview and perspective of larger issues has been inadequate and productive of insecurity and social tension.

(b) The conduct of social policy under these conditions has, in many cases, been forced into continuing postures of crisis management. Decision making at the regional, national, and international levels has specifically lacked the longer-range *social navigation* aids and "early warning" systems that might have made for smoother transitions in critical change areas and allowed for the degree of anticipatory long-range planning necessary to our forms of complex sociotechnological society. The scale of human "intrusion" into the environment has reached critical magnitude only in the past century—and the majority of institutional arrangements have evolved in earlier periods, when the time, scale, and margins for error were much greater.

(c) In recent years, this awareness of inadequacy in our "societal feedback" and anticipatory control systems has led to the proposal and development of various types of longer range "social accounting" and forecasting, etc. An example of the most recent of these is the "Social Indicators" movement.[8] The inauguration of the National Goals Research Staff at the highest legislative level was also a further manifestation of the urgent need to increase *integral* social awareness of the complexity, long range consequences, and implications of all aspects of the local society's problems and to focus attention on the need for more adequate measures of social development within a larger framework of specific goals and values and their policy options.

(d) The Timetable study should be viewed within this outlined context of societal relevance as attempting to develop a more precise overview and awareness of the interrelated complexity of our major problems and to communicate the *time, range,* and *scale* of their critical proximities. Its findings would, therefore, be addressed in various forms to the largest audience, and its ongoing synthesis of social navigational trend information would be of continuing value to other agencies and institutions engaged in other problem-solving and goal-definition areas.

B. *The educational relevance* of such a study, as conducted within the university, with a relatively large group of students, lies in its provision of an opportunity to confront "problem-oriented education" [9] in an innovative manner that would allow students to work at such a study in an active research-team project design rather than in their customary passive course-taking role and that would encourage the development of a genuine *transdisciplinary* educational base that would draw on, for example, a generalized knowledge of the basic sciences—social, as well as physical, chemical, and bio-

logical—and of the ways in which these contribute to the overall conceptual whole of the study. Assessing the scale and magnitude of human trends in the past period would lead to involvement with socioeconomic, scientific, and technological histories and case studies in a somewhat different manner than through more specialized course work in these areas.

Considerable attention would also be given to the current range of forecasting methods and techniques and to their validation and practical use, for example, in ongoing policy decisions in various problem areas. Students would also be introduced in a real-work situation to the various sophisticated systems-analysis and forecasting methods available. The compilation, indexing, and coding of human and physical-resource base information will require student work teams to review and develop efficient information storage, access and retrieval —including E.D.P. systems and computerized techniques.

Because the presentation of the results of the study would be designed for a variety of audiences, there would also be the concomitant exposure to, and use of, the range of communications media that may be employed for different audience ranges and purposes.

In these various ways, the educational framework of this study would also be unique in that the students would be initiating and organizing their own work-group situation and allocating various organizational member functions; directly consulting with, and being exposed to, various individuals and authorities in the university, industry, and government; and coordinating their own work internally in close collaboration with other groups working in contingent areas.

Assuming that the above first-year phase was confined to graduate students, one could in the second year of the program use a *multiplier* effect to seek the largest feasible real involvement of undergraduates by attaching to each graduate researcher a number of undergraduate students who would then form an extended group engaged through seminars and direct work in the ongoing program. In this fashion the project could be gradually expanded to become an important self-generating focus of creative involvement for the university at large. A not inconsiderable aspect of such direct involvement and confrontation with world problems in a systematic way is that it would provide meaningful answers to the searching and often turbulent questions that are today asked both of the university and of the society.

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Working Group
CULTIVATING RESOURCES: OUTER SPACE, ATMOSPHERE/SURFACE, OCEANS

Chairman: Ross Nigrelli

Cochairman: Solco Tromp

Participants: Raul Aglion, Elisabeth Boyko, Hugo Boyko, Joseph Cunetta, John R. Davis, Jacob Feld, John Fionanda, Douglas Johnston, Serge Korff, J. Warren Nystrom, Francis Perrin, John R. Platt, Boris Pregel, Victor Salkind, Theodore Shedlovsky

NIGRELLI: I guess the idea is to give some precise evaluation of the several topics in the space and earth sciences and probably come up with some conclusions or recommendations that might be integrated into the total symposium.

DAVIS: I would like to give a brief presentation on what is going on in our national space program with regard to the survey of the oceans, mineral resources, the atmosphere, et cetera, as a point of departure. We have a number of national programs. My regular job is staff responsibility within the Environmental Science Service Administration for our satellite and space-science programs. As such, I am the Commerce Department member on, if you like, the Board of Directors of the Earth Resources Satellite Program, which is called the Earth Resources Survey Review Committee. This is a United States Government program. The actual program is operated by NASA, which has responsibility for all of our research and development in space, but it is guided by representatives of the Departments of Commerce, Agriculture, and Interior. It is concerned essentially with the fields of geography, geodesy, oceanography, hydrology, agriculture, and resources survey in general. There are a number of programs at this time, starting with the original meteorological satellite programs that have now been refined and extended into the areas of hydrology and solar and upper-atmosphere forecasts. These are now operational programs. They are operated by our group. We have a complete spectrum of devices that will obtain data about the sun, space, the upper atmosphere, the lower atmosphere, et cetera. I think it would be futile to sit here and try to cover these topics. I will mention only the earth resources survey program.

Not too long ago, President Nixon announced this program and said that the data that would be ultimately obtained would be made available to all interested nations. I think perhaps a certain amount of confusion came from that announcement, because I think many people associated our present experimental program with an ultimate operation. I want to make it very clear that what is now going on is essentially an experiment.

We are attempting to find out to what degree we can actually identify, locate, and quantify resources from an observation in space. The basic approach to the program has been to use several regions of the electromagnetic spectrum. The principle is what is called the spectral signature. The idea is that a crop of a certain species will have a certain reflectivity in the optical region. It will have a slightly different reflectivity in the near-infrared. It will have certain thermal emission properties in the thermal infrared. It will respond

slightly differently in the red portion of the optical spectrum than it does in the green, and so forth.

By looking at the earth through high-resolution multispectral sensors, the hope is that a given species or a given mineral will have a unique signature in terms of combination of those four or five or six regions of the spectrum. Experience to date from aircraft experiments has indicated that to a large extent this is true, particularly if a time sequence is introduced. For example, in this particular observation, which simulated the earth resources experiment, Apollo 9 had hand-held photographs taken by the astronauts with cameras that simulated the spectral regions on the earth resources satellite. They came up with a well-known series of pictures on the Salton Sea area in California. They were taken in false color in which the shades of red were in proportion to the temperature. They are actually composed of three channels of black and white, two of which are in the optical and one of which is in the infrared.

With this type of analysis, we were able to correctly identify something like 60 percent of the crops. This was followed by a series of aircraft photographs simulating this resolution and coverage—a series of three flights, one of which was on the same day as the satellite. Another was some two weeks later and the last two weeks after that. Using the time sequence, they were then able to identify something like 96 percent of the crops. With use of the time of the year as well as the spectral response, the probability of correct identification was extremely good. This method, we believe, will apply principally to the world's major food crops. In other words, wheat, corn, oats, barley, rice. When I say major, I mean crops normally planted in rather large areas, let's say ten acres. If you study ten acres or more, this kind of resolution is quite good. It will probably not be useful for what we call luxury crops, like lettuce and radishes and things that are normally grown in smaller fields.

The other aspect that's quite good is that you can detect stress to a crop very early, even before it's visible to the naked eye. It seems that the first thing that happens when a plant is sick or infested with insects or has trouble with salinity or drought is that it runs a fever. There is an infrared change, a visible change in the color of the leaves. So, it is possible to detect very early a difficulty with a crop.

TROMP: You mean an experienced plant pathologist would not see it in a plant on the ground?

DAVIS: Not as early.

TROMP: Not as early as that?

DAVIS: That's correct. It doesn't mean that if you were on the ground observing this in the infrared you wouldn't see it. We have a number of photographs from aircraft with test panels. For example, in west Texas, at the agricultural experiment station, they have panels of cotton, and they can vary the irrigation, so they'll have water shortage on one, a normal amount on another, too much on another.

TROMP: Is it the difference in thermal radiation emitted by the plants?

DAVIS: It's true that there is a difference in thermal radiation. In the thermal infrared, the temperature difference of a sick plant is as much as 10°. This is, of course, particularly true with drought, water starvation; the temperature goes up. However, even in the reflected infrared, the near-infrared, the character of the reflection changes.

ELISABETH BOYKO: At what distance from the crops is this taken?

DAVIS: Apollo 9 was, as I recall, about 150 miles up.

ELISABETH BOYKO: And this would be sufficient to see?

DAVIS: Yes. As a matter of fact, the actual experimental satellite will be at an altitude of approximately 500 miles, and it will cover a swath approximately 100 miles wide, and its resolution will be approximately 400 feet. This, for example, would be a television presentation, not a hard film.

The same general approach has been taken to such things as forestry, classification of types of cover, range land, et cetera, and it is most useful when it is used in connection with other types of survey. Nobody has suggested that everything that needs to be done can be done this way. What the satellite does is give you the big picture and identify essential trouble areas; for example, gross acreage estimates, gross indications of drought. Then what we've done is to set up a successive sampling program. You look at a picture that identifies where there are crops and where there are none and what their general types are. Particularly in forestry, you fly an airplane in, sample another area, and relate that one to the aircraft picture, and then finally you relate the aircraft picture to visitation on the ground where the actual volume, let's say, is measured. So now you have a statistical means of building up a picture of the entire area by use of satellite. This type of survey requires something like 1/100 of the manpower and the time that would be required to make the survey by conventional means. The one we did was a rangeland survey, not detail crops. In the rangeland survey we identify five different types of cover. The first thing the satellite does is to indicate those areas where there is no cover, so you don't have to worry about those. You identify five different types of vegetative cover. The airplane goes over sample areas of those five and gets better identification. Finally, somebody on the ground identifies the species. Then you build a picture backup and you come up with the total volume of each type of cover in a region.

TROMP: Do you get the same picture whether it is a hot day or a cold day?

DAVIS: No. The satellite provides uniform illumination and sun angle over a large area. If you do this from an airplane, you take pictures over eight hours or maybe over several days, and the illumination would not be the same. Taken at different times of the year, they will look a little different.

TROMP: If it is taken in the morning or in the afternoon, whether it's warm or cold—it doesn't make any difference?

DAVIS: It will make less difference in the reflecting infrared. It will make more difference on the thermal infrared. But again, you would be looking for contrasts. One of the reasons we call this simply an experiment is that we have exactly that kind of question to answer. A body of data must be built for us to know how to use these before they can be applied.

SALKIND: To what extent does this method tell about thermal sources?

DAVIS: This is one of the other areas that was of interest to start with. There have been experimental plates in the region of volcanoes, for example, and other types of thermal studies. In particular, it is very good for identifying geothermal sources. And there is reason to believe that it will identify incipient eruption of a volcano. That is, the temperature starts going up around the volcano prior to the actual eruption. Sometimes it's a matter of ten days to two weeks before the actual eruption.

SALKIND: What about the geothermal gases or vapor that is still under a cover; it doesn't come to the surface?

DAVIS: If it raises the surface temperature, it will show up as a warm spot.

SALKIND: Do you think it would be possible to identify ground water reservoirs, shelf ground water reservoirs—which may, of course, affect the surface temperature, although not essentially?

DAVIS: It does tend to affect the vegetative cover and the appearance of the surface, and therefore we are able to make estimates.

SALKIND: Yes, but if you have a desolate area that may have ground water but no vegetation on the surface—

DAVIS: There is a fairly good correlation between thermal infrared and the water content, and this is one of the signatures that one must explore.

In addition to soil coverage, there has also been work done with the spectral signature of different types of soil as well as the same type of soil with different humidites. Work has also been done on identifying different types of rock and types of strata.

SALKIND: Can you distinguish between fresh water and polluted water?

DAVIS: Generally speaking, you can distinguish between fresh water and polluted water in two ways, and we've done both. In a river or harbor, a source of pollution will, first of all, tend to be either warmer or colder than the surrounding water. Secondly, there will usually be a difference in turbidity, due to sediment or perhaps a different color of sediment, and the reflectivity may be different in different portions of the spectrum.

SALKIND: How about fresh versus salt water?

DAVIS: Again, usually when fresh water comes into salt water, it is not at the same temperature, and this helps you detect it. Also, it probably is not precisely the same color in all regions of the spectrum. I've seen some pictures of a river delta where you can clearly distinguish five different water masses.

The other thing that we have investigated is the identification of thermal boundaries of the ocean, the location and type of sea currents. For some reason, these boundaries tend to be the regions where fish concentrate. In other words, there is a gradient of temperature and a gradient of oxygen, and somewhere along the gradient will be the place for a species of fish. We don't do thermal fishing very much in the United States, except off the West Coast. However, this is of very great interest to the Brazilians and Chileans and to several other South American countries.

Early in this program—almost at the very beginning—we recognized that it would have international implications, and one of the very first things we did was to involve several of the countries that expressed an interest. So it has had an international flavor from the very beginning, although again we have tried to make clear to everybody that this is an experimental program and that they are joining us in the experiment. I think it is most unfortunate to give anybody the impression that we are going to solve all of the world's resource problems. But we feel it's a tool.

TROMP: The mapping of sea currents is certainly much quicker if done that way. Can you calculate the difference in cost between this method and sending boats out?

DAVIS: If you assume that you are going to map, for example, global distribution of sea surface temperature, then I think it's extremely cost-competitive. Maybe you don't make that assumption. But if you want the global distribution, then I think you need a satellite. A satellite has the virtue of seeing a large area of the world, and seeing it very nearly at the same time. I think it's a mistake to try to link the satellite to everything. If you want to really look at Long Island or a small region, you don't need a satellite. If, however, you want a global picture, then the satellite is good.

In a different program, with the ITOS weather satellite, which will become operational in June, we have for the first time routine daily visual and infrared coverage of the whole world. With this satellite there is also a higher resolution than with the older ones. We will begin acquiring sea surface temperature data, and we will be mapping the sea surface temperature probably two or three times a week; by next fall or winter we will be issuing a daily map of the world's sea surface.

TROMP: How many photographs do you take to do that?

DAVIS: That particular program is not analyzed photographically, because the original data come in in electronic form, by television, and so it is automatically digitized and rectified and averaged. The whole process is automatic. The sea surface temperature will entail no manual reading of photographs.

Again, in the earth resources program we will count acreage without the necessity of looking at a picture. We may use this satellite for several other types of application. One is what you might call reconaissance hydrography, looking for gross coastline changes. We can determine where a vessel should go in for a new survey. Another application has to do with the location of mineral deposits. This, of course, is where most of our political problems are at the moment. If it turns out that this is a useful tool, then it becomes extremely controversial. It has to do with detecting gross geological structures. If you were to take aerial photographs of this area, you would perhaps have 20 pictures. They would have different contrasts, different exposures, different sun angles. You would miss large geological patterns; several times we picked up patterns that we hadn't seen before.

SALKIND: Let's say you make this photograph from the satellite on a clear day, and you get the pattern from the air. The next day the air between the satellite and the surface contains a higher percentage of humidity, which certainly will produce a different picture. After making the first photograph, you draw your conclusions. But the next day or in two days you make another picture of the same area, but under different meteorological conditions. Wouldn't this confuse your conclusions?

DAVIS: It would, except this happens to be one of the research programs that my office is responsible for. Part of our organization also includes a group at Boulder that concerns itself with propagation in general. One of the things that one must do in developing spectral signatures, or any other form of sensing, is to correct for errors in propagation. We want to correct, if possible, along the track and part of our study concerns the means to do that in connection with the satellite program. In terms of the immediate future, this can be done by the availability of data we plan to have in 1972. In 1972 we will add a new system to our weather satellites that operationally will give us two things. It will give us temperature as a function of altitude on a global basis, a temperature profile to the cloud cover or to the surface, and it will do this to about a 30-mile resolution, so if it picks up a hole in the clouds, it will go through. At the same time, it will also give us the moisture profile over the same regions.

With the NASA BTS Satellite we are now obtaining temperature experimentally this way. Last year we went suddenly from about 400 upper-air observations to 10,000. We believe that in 1972 we will have these propagation figures. And in the cloud-free areas we will know at least that day what the humidity profile was or, certainly, what the total humidity was, and what the temperature profile was. So we will be able to make propagation corrections, at least of that nature.

Another program I haven't mentioned has to do with very, very accurate measurement of the earth's surface. The purpose of this is to measure the surface of the earth from a satellite with an accuracy of 10 centimeters. We don't plan to do this until the end of this decade. However, we do propose, by about the middle of the decade, to be able to do this with an accuracy of 1 meter. Even 1 meter is extremely useful. It permits you, for example, to gauge the slope of the sea or the shape of the equipotential surface over the ocean areas. This is done by a combination of a geostationary satellite, whose coordinates are precisely known, and a lower-altitude satellite. This eliminates the propagation error. The system will require an instantaneous measurement of propagation error, which will be done by the use of two different frequencies.

What is exciting to us in this program is that by 1977 or 1978, we will for the first time be able to observe the entire earth. We will be able to observe earth motion; we will be able to observe the dynamic earth tides and the general circulation of the ocean. Through a combination of the sea surface temperature and the equipotential surface we will be able to observe the entire globe dynamically. Not only will we measure distances for geodetic purposes, we will be able to actually measure the dynamics. I find prospects from the scientific point of view very exciting. I think they have considerable potential for application as well. I don't want at any point to imply that we think we have the solutions to all problems. But it is important within the context of our discussion over the next decade to realize we are going to have such observations developed.

JOHNSTON: Within this same context, we might consider the enormous implications of a system of detection of the earth's surface from outer space. I feel it should be considered by the international scientific community represented here. For example, by what criteria do you decide on the various programs to be undertaken under the general satellite program? More specifically, what do you decide to equip your satellite to detect? Why one kind of environmental problem rather than another?

DAVIS: That's a good question, and it's a good question within the context of the United States at the moment. The answer, I think, for the immediate future is that we are now extrapolating our technology. We are first investigating as broadly as possible the potentials of multispectral high-resolution sensing from space. And we are doing certain additional experiments, if money permits, on the manned laboratory that NASA plans to fly also in 1972, in which we will have some ten channels of infrared and optical frequency, plus another four-channel microwave.

JOHNSTON: Does this mean that you do everything that technology enables you to do now?

DAVIS: No. What it means is that we are investigating at minimum cost what can be done and what we can do. We have identified what we believe we can do and what we will attempt to do. We will find the degree to which we can do it. Our immediate intention is to work within the context of our own national programs. Because, as you know, the more people that are engaged in the decision-making process during the research phase, the more difficult it is to do the research.

Incidentally, the data even from the experimental program will be available to anyone who wants to write for them.

JOHNSTON: It wasn't meant to be a critical question. It was an honest question in terms of the world community in general. To take a fairly peaceable hypothetical situation, at this very moment, region X somewhere in the world may have, unknown to it and everybody else, a heavy incidence of a particular crop disease that could be detected by an American or any other national satellite to give early warning to that country. That's one kind of problem. You could make a long list of problems that might exist right now and yet have never been detected. That being so, how does the international community have access to decisions that also have to be made within the national program—what to detect, what to try to detect, and what kind of technology to put into the central input for detection purposes?

DAVIS: The answer to that depends on the phase of the program. In the early phase, the experimental phase, there will be no tape recorder, so there will be no capability for other than direct read-out. When there is a tape recorder, it will not be able to operate more than about 30 minutes a day, and at that resolution that's not very much coverage. So, in the early stages we will not plan on much international coverage. We had a long meeting on this in Annapolis in which many of these subjects were discussed. The question is, Do you go through the ordinary disciplinary structures? For example, do you do it through our Department of Agriculture, which has communications with other departments of agriculture, do you do it through a central data facility, or do you go through the UN itself, which operates a data facility? We feel at this stage that none of these questions can really be answered until we have a better understanding of the nature of the system and what it will do.

JOHNSTON: But looking forward, as we're asked to do here, to the '80s and '90s, by extrapolating technology, presumably we can assume there will be greater capability and that a wider choice of decisions can be made. That being so, perhaps the question should be: What does the international scientific community feel is the way to go about determining the criteria for such selection?

DAVIS: I suggest that our experience in meteorology leads us to believe that we must consider our data output on three levels of needs, which is what we do in meteorology. On the first level we identify a tropical storm or some other immediate threat. This goes directly from the satellite center itself to the weather services of the country involved. The next level of needs would be, let's say, the daily forecast. This is transferred from the satellite center to the weather bureau, and the weather bureau puts it on its teletype service, and it goes out. And then finally there are the research data, available by mail. I suspect that whatever system we set up on an international basis is going to be roughly the same. In other words, anything that constitutes an emergency should go through as few channels as possible. That which is required for forecasts should go out through orderly but rapid channels. And that which is used for research can be made available through the mail.

The first program to apply in late 1972 will have three channels, which will be roughly 0.5 to 0.6, 0.6 to 0.7, and 0.7 to 0.9 microns. The next one, which will apply about a year later, will have those and will add a channel of roughly 10 to 12 microns, somewhere in that region. The series that will follow, if it is approved, will concentrate principally on oceanography, and therefore it will have more infrared. It will also have microwave sensors.

TROMP: I think they are doing similar work in the U.S.S.R., aren't they?

DAVIS: There has been some discussion there. They have announced that they intend to do so. But we haven't any real information as yet.

NIGRELLI: I don't want to carry this too long. I think it is obvious then that there are going to be things that we can look forward to in the next few years in the use of these satellites for world survey of our resources.

DAVIS: Incidentally, I forgot to mention that the plans are for selected sensors of temperature, humidity, or whatever, and for the transmission of data directly by relay through the satellite down to the ground station. This type of data could require seismometers, for example, to get earthquake information. In fact, again in '72, there will be planned another satellite with a seismic sea-wave warning service via the satellite center, which will relay seismic data as well as tidal data. It seems to me that we are talking about an era when we are going to have what amounts to a universal tool. If you add this tool to the tool of fourth-generation computers, which we anticipate during the same time period, we will have the ability to model the environment. Until we can really model the environment, we don't dare attempt large-scale weather modification.

Undoubtedly, during the decade, we will be doing some operational weather modeling, such as reducing the force of hurricanes. But we don't dare do large-scale climate changes until we have a good enough model by which we can clearly predict the consequences of such action. And I think the combination of those two tools—satellite observation and data collection, plus the fourth-generation computers—is going to provide us with what amounts to a universal tool. I would like to make a plea that when you have a universal tool, it's a good time to try to make your science more universal also in order to relate disciplines to one another.

JOHNSTON: Have there so far been any international scientific conferences to discuss future uses of this universal tool, or is this something we can recommend?

DAVIS: I don't think it has been discussed in that context. One of the irritations I experience when I go to international or national meetings is that I must choose this room for oceanography or this room for meteorology or this room for biology, and I can't go any place to talk about all of them together. I think if this group can do anything to encourage interdisciplinary science, it would be highly advantageous.

NIGRELLI: You did mention that some information could be obtained on the distribution of our ocean resources. Does that include only the living resources? How about the mineral resources?

DAVIS: It includes both, really—the mineral and the living. One of the things I forgot to mention is that there is some indication of a good correlation between chlorophyll content in the sea water and biota in general. The chlorophyll content tends to attract the microorganisms, which tend to attract the smaller fish, which tend to attract bigger fish. You can detect differences in chlorophyll content by this method and, thus, areas where there are more likely to be fish.

NIGRELLI: With regard to minerals, as you suggested, you are going to need some very close observation. There are many areas where chlorophyll content is very high and yet fish are lacking. There are areas like that in the ocean.

JOHNSTON: How long do you think it will be possible to pinpoint by

satellite promising new fishing grounds that haven't been discovered yet—the 1970s, the 1980s?

DAVIS: Well, I don't know. If you can do it at all, it ought to be possible sometime within the decade.

KORFF: You can certainly also measure temperature changes in the ocean, because with heat sensors you can tell where warm currents are exuding.

DAVIS: One thing that has been done, incidentally, is to locate loss of fresh water. They're doing this in Hawaii and in Mexico. Hawaii has a serious problem of freshwater loss. Instead of staying where it should, it's exuding out along the coastline; and this is very easily detectable with infrared techniques. Then you can put a well right there where fresh water is being lost.

JOHNSTON: If you can measure temperature, you can detect salinity and you can photograph upwellings of the ocean, among other things?

DAVIS: Right.

JOHNSTON: By putting these things together, you would be able to detect where the most likely places for fishing would be?

DAVIS: No question about it. The Brazilians are very enthusiastic. Unlike us, they are today making fishing forecasts. They make three-day fishing forecasts right now for the industry. They're excited by the prospects.

JOHNSTON: I don't want to be repetitive, but I asked a question earlier about criteria for selection. The United States is not a major fishing state. There are many smaller countries that do depend very heavily on fish for the food supply. If it's an American national program, you have to assume that the people who make decisions as to what to observe from the satellite would not be particularly concerned with fishing development for the future. This is one consideration.

DAVIS: I'm not in a position to make national policy, but my guess is that we'll get around the problem of who gets the data and how probably by transmitting it through direct read-out, very much as we do with the weather ABT now. And we'll leave it up to industry. If they want to read it, they can read it and do whatever they like. This would solve the problem, I think, in the easiest possible way.

TROMP: FAO is already giving out a lot of this fish information.

SHEDLOVSKY: I would like to put in a plea for its not being 100 percent effective because of the danger of extinction of a species.

DAVIS: This is a good point. I think it's part of the broader context of the kinds of questions we're asking. It's a matter of policy, I think. I agree that there are some very serious policy questions.

SHEDLOVSKY: The probability is that whales will soon be extinct.

DAVIS: One of the things you can do, I suspect, is to monitor the environment. On the assumption that someday there will be an international desire to control pollution and control activity with this type of surveillance, you will know very well if somebody is not properly preventing pollution. You can very easily pick up both heavy smoke and thermal pollution.

JOHNSTON: We might want to consider later the proposal that there be read-out facilities provided to such international organizations as FAO and to do whatever seems desirable for international purposes.

DAVIS: I don't want to anticipate the operation of the system. In other words, we don't at this time know what kind of system it will be. We don't know which sensors will work best or at what altitude they will fly or what the repetition rates will be. The experimental system, for example, will cover each spot on earth once every 18 days. I think it would be a serious mistake to confuse the operational system with the present experimental system.

JOHNSTON: Obviously, budgetary considerations will arise in the 1980s and 1990s that we can't anticipate. That being so, we ought to consider that there should be some kind of non-American contribution to your budget for the development of international benefit and concern.

DAVIS: In one document we have distributed we have indicated that this is for experimental purposes, and we have also said that we would welcome the participation of related agencies.

JOHNSTON: So far this has not been forthcoming?

DAVIS: I think it will be, frankly. We have also suggested that the United Nations or some organization play a central role as a source of international data.

JOHNSTON: Do we, as scientists, feel that the proper agency inside the United Nations is not a political one, that it should be something like the FAO or the WHO? Do we feel strongly about this? Do we want to make this clear to our proposals?

TROMP: FAO is a rather efficient international organization.

DAVIS: I think there may be a number of organizations. Speaking of the ocean, that's another program proposed for 1976.

NIGRELLI: How is this related to your program?

DAVIS: Not to the earth-resources program. We will probably use our so-called geostationary satellites. We have so much happening in 1972 that I don't know how we are going to handle all of it. Number one, a moisture and temperature sounder will be operational in '72. We've got the first earth resources satellites in 1972. We've got the first geostationary operational satellite in 1972. And we've got the NASA manned space lab slated for 1972. That's going to be a fantastic year or else a tremendous fiasco; I don't know which.

NIGRELLI: Are there any other areas that you want to bring up?

TROMP: There is another project that I wonder whether we could discuss. There is no international organization that handles the question of international training centers in the developing countries in which people are trained on the effects of the physical environment. FAO is interested in that.

NIGRELLI: Aren't there any such programs now?

TROMP: Not on the physical environment.

NIGRELLI: Does anybody have anything to say about that idea?

TROMP: FAO would be interested. They have many people working there. There are all kinds of migrations of insects that are not studied in connection with the physical environment. I think FAO would be the best-suited organization to undertake this project.

NIGRELLI: Let's take the fisheries. Doesn't FAO now go into a country and advise them?

TROMP: And on top of that, these problems are not just in one country. They apply to the whole of the Middle East, for example, or to large regions. There is only one expert, a good agriculture man who may know about crops but doesn't know anything about the physical environmental effects. That's another specialty. FAO has an interest in the subject, but they are not sufficiently pushed by outside sources.

NIGRELLI: I think we might put that on the agenda for further discussion. It seems to me that the two major topics have been the improving and increasing

of our resources, food and mineral resources. The other is improving our environment.

JOHNSTON: I thought we might list a number of questions that we should discuss more extensively. There are three categories I think we have to think of right away in the area of policy implications. First of all, values, preferences, norms, standards, rules—these would be one category. Second category: institutions. What about the existing institutions in the world, national, international, regional, whatever they might be? Are they good enough? What do we think of them? And the third category is procedures. Are they working properly? What about the operations of these institutions? Why aren't they working properly? What do we think is wrong with them, and how may they be improved?

We could probably begin with these three categories of problems in terms of policy implications. What's wrong normatively, first of all, about the internatioinal community in the context given here of resources in the four environments? There is something missing in the world. What are the norms that we need to introduce?

At least five criteria occur to me that suggest themselves as relevant. First of all, security. Do we feel that the existing norms, laws, rules regarding the use of outer space contribute as much as they should to security? Has enough been done, for example, in treaty-making to ensure that space will not be used for war-making purposes and that space should not be used for the carriage of satellites that constitute threats to the security of any people on the earth? That's one category. You can extend it further and ask whether the satellites that are put up for scientific purposes, for peaceful purposes, are necessarily being used for preventing threats to health and well-being as much as they should be.

That's why I raise this question of who selects the research projects of a satellite program for the protection of the earth's surface. Are we as scientists complacent, satisfied? Maybe we should be. That's not a critical question; it's an honest question. How can we be satisfied that the health and safety of all people in the world are receiving as much attention as they should when we decide to give the satellite for purpose A rather than purpose B? I just raise the question. That's category one, security.

The second criterion is scientific intelligence. Do we feel from the point of view of knowledge, the collection of information, that the correct scientific decisions are being made?

The third criterion would be that of efficiency or skill. Do we feel that there is as much avoidance of waste as there should be with respect to resources in outer space or any of the other environments? Are the resources of the environment overused, underused, misused in serious respects that ought to be recognized and brought to the attention of the international scientific community that we represent?

The fourth criterion might be that of good will. Do we feel that these environments, resources, have been used to have a maximum effect on the improvement of good will throughout the world? Do we stimulate as much cooperation as perhaps we might to allay distrust and suspicion?

The fifth criterion would be that of wealth. In the development of resources, do we feel that these environments are being used as they might be to stimulate development for the benefit of all?

PERRIN: I wanted to say that the thing we should discuss a little more is the question of pollution.

FELD: You must define pollution.

PERRIN: I spoke earlier about pollution from sulfur dioxide. Then we have pollution from exhaust gas by automobiles, which is mainly incomplete combustion of gasoline, which leads to carbon monoxide.

FELD: In industry, one of the worst offenders for dirt and dust and gas has been asphalt-producing plants. They belch dust and refuse from oil, and they use the cheapest kind of oil. One of the plants that wanted to eliminate this because of residential objection in the neighborhood installed sonic water atomizers in the chimneys. These are little jets of water that in themselves don't do much good. But by putting in a separate series of jets of very high-pressure air, the water jets became atomized by cross-motion. They are removing 98 percent of the dust particles from 3- to 15-micron size from the chimney smoke, and 80 percent of the particles less than 3-micron size. You see practically nothing come out of the chimney. And the total cost of that was something like two or three cents per cubic yard of asphalt produced, which costs now about $12. So it's nothing in cost.

PERRIN: It's a very nice example. In aluminum production, a large amount of fluorine dust is spewed out of the factory if there is no special protection against it. It should be forbidden to throw in the atmosphere this dust, which is destroying the vegetation around the plant.

FELD: As to aluminum, here in the United States the Reynolds Aluminum Company, the second largest producer of aluminum products, is now controlling its emission of dust, and to counterbalance the cost of that extra work, they are reusing aluminum scrap in their products and balancing their budget. These things can be done. They find that advertising that they are removing pollution from air, water, and soil is very good for business.

KORFF: I would like to bring up an illustration of a problem for which we do not know the solution. That is the problem which I think has been misunderstood, of the generation of smog in the atmosphere from automobiles. It is not a question of incomplete combustion from automobile exhaust. The smog of which I speak, which you're all familiar with—you've seen it in Los Angeles and elsewhere—doesn't come from incomplete combustion at all. If you wish to generate smog in a smog chamber, as an example, all you need is a cubic meter of plastic. You put in it a lamp that will generate ultraviolet. You take one teaspoonful of unburned gasoline and tip it up so that it evaporates. It is unburned gasoline, not incompletely burned. This does not come from the automobile exhaust. It comes from a totally different source. Every time you fill the tank of your automobile, 10 gallons of gasoline vapor, unburned, goes into the air. Every time a truck draws up to the gasoline station to fill its tank, 10,000 gallons of air are saturated with gasoline.

Nobody has suggested any good means of stopping this. Putting pollution-control things on the bottom ends of automobiles wouldn't help much; the main source of this particular thing is not stopped up by these means. The unburned gasoline vapor, combining with ozone, which in turn is generated from oxygen by action of the ultraviolet light, is what causes the corrosive organic acids that are characteristic of smog. This is a different generation of problems. California has a smog research program. I've discussed this with people there. They're all aware of it, and nobody has as yet come up with a good answer to this

particular problem. There are many other cases. If you spill a gallon of gasoline, then the entire gallon goes. Your blow-by in the automobile—a small amount of unburned gasoline—goes out of the crankcase. All the time the car is exuding unburned gasoline as well as the things that you were talking about.

PERRIN: Yes. Is there a research program?

KORFF: Yes. This is a problem really for engineers.

FELD: Isn't it possible that gasoline is the wrong fuel?

PERRIN: Nuclear energy is of no use until there is a spectacular improvement in the accumulator.

FELD: I visited a manufacturer of motor vehicles and motors, and he showed me a completed automobile that he had developed and wanted to put on the market, and I haven't seen it on the market. It had two engines in it. One was an electric engine, run by batteries. And the other was the normal gas turbine run by compressed butane gas. The idea was that the engine to be used depended on the locale. When you were within city limits, you used the electric engine. The speed limit was restricted to 30 miles an hour by the engine itself. When you left the city, you used the gas turbine, which, in addition to running the car, would also regenerate the batteries, which could be regenerated by other means as well. A gas turbine with compressed butane has practically no exhaust. It results in complete combustion and use of fuel.

KORFF: And no filling spillage.

NIGRELLI: The last suggestion made was to outline those problems that we know can be technically corrected and those problems that have yet to be solved.

JOHNSTON: I think there are four areas of problems discussed this afternoon. I think the discussion of antipollution measures—the distinction you mentioned is relevant: the pollution problems that cannot be solved immediately because of lack of knowledge and those that can be solved by the application of technology. The second area that I think we discussed rather extensively is the survey of the earth's resources from outer space. The third area, just touched upon, is the problem of interdisciplinary cooperation, and here we have to confine ourselves, I think, to our context, which would be environmental resources. The fourth area—again, just touched on, we could take it much further—would be the problem of improving training programs for underdeveloped countries with the protection of the environment specifically in mind.

DAVIS: One area that doesn't seem to be included is the development of resources. Somewhere, it seems to me, we can do more than merely worry about the pollution.

JOHNSTON: Right, development of resources. There has been no discussion of this, and that's all the more reason for it to be taken up.

FELD: I think we can also add the storage of waste or refuse for future natural resource development. I would like to see those trenches in Pennsylvania where the coal was taken out filled with smashed-up automobiles and made future iron mines.

JOHNSTON: That would be six areas, then.

FELD: Isn't it more economical, as many companies are doing, to plant trees to be harvested 100 years from now? Why not take rubbish and put it away for 100 years? There are holes in these mountains where the coal has been taken out. Fill them up with iron scrap.

DAVIS: We have solved the local problem in our area, around Chesapeake Bay, and also gained a distinct advantage. There is now dumping in the bay to create reefs, because there are no reefs in Chesapeake Bay. You get rid of the automobiles and create reefs.

FELD: Yes, but you are eliminating future use of that metal, aren't you?

DAVIS: Not necessarily.

FELD: Unless you go into underwater mining.

DAVIS: The metal will eventually erode away.

FELD: Don't you see, you cannot throw this away! You are robbing future generations of the reuse of this material.

SALKIND: If you put it underground, you will not contaminate ground water with iron oxide?

FELD: I have iron oxide in my ground water.

DAVIS: The reason why you have this problem is that they changed the method of making steel. At one time they used a large percentage of scrap steel. When they came up with the new method, the price of scrap steel dropped from $16 a ton. The cost of removing the paint and rust and dirt from old automobiles was $20 a ton. So they stopped doing it. The mills would take only prime mill scrap. At one fell swoop this created what we see around the country today.

FELD: But you can take automobiles and squeeze them, dump them, or shred them—the wood, paint, and everything—shred them and dump the shreddings into the ground.

KORFF: After they have been shredded, you can pass them over the table and separate the iron out magnetically, because there are all kinds of things in an automobile, such as copper, that you don't want in the steel. After that, you melt what's left in two different piles.

FELD: You can develop future mines.

NIGRELLI: The broad question is the conservation of scrap.

FELD: Give it a higher-sounding name and your chances are going to improve. I know that the junk dealers in New York City many years ago were called "junk dealers." And then someone thought up a new name for them—"Reclaimed Metals Association." And they are now a high-class, very well-thought-of organization.

NIGRELLI: What about old bottles and plastic?

FELD: Glass is being used experimentally as an aggregate for masonry materials and for roads. The universities are doing a lot of work on it right now.

KORFF: What do you do about plastics?

FELD: For plastics there is no disposal.

DAVIS: Or they might constitute a raw material for future plastics.

FELD: Future plastics, yes.

DAVIS: Is there a general title such as "resources for the future" or something of the sort?

FELD: Conservation of the earth's resources. That's the basic problem.

TROMP: Can't you burn up plastics at very high temperatures?

FELD: Of course, you can.

TROMP: Would that not be economical to do?

FELD: Yes, but why burn it up if you can reuse it?

DAVIS: Or you might even fractionally distill it.

FELD: If you burn it up, you are losing the energy that was consumed in making it. You can use refuse as a fuel. You can use the energy from anaerobic disposal of sewage. At the plant we are working on now in the Hudson River,

here in New York City, we shall take care of 220 million gallons a day. The gas production is being used for electricity production right in the plant and for heat control and for air conditioning, temperature control. There is a possibility of surplus power generated in that plant. This is purely from the hydrogen sulfide and the hydrogen produced in the sewage tanks.

KORFF: And methane.

FELD: And methane, yes. This is all combined in boilers and also to some extent in turbines.

NIGRELLI: And produces more pollution.

FELD: No. I've suggested this, and people are working on it—the exhaust gases from the boilers are to be recycled through the boiler to be used as combustion air, so that you get a second burning of the material in the gases. The second exhaust is then percolated through the river of water, giving a temperature rise in the summer and control of ice in the winter.

NIGRELLI: You're going to get embroiled with the conservationists.

FELD: They're already on our necks. As a measure of proof that we recognize the necessity for considering ecology, we are putting steel icebreakers north of this plant in the Hudson River that are roosting places for the seagulls.

JOHNSTON: I wonder if there is any journal at present in the world that specializes in storage-of-waste problems.

FELD: Oh, yes. There are several published by McGraw-Hill.

DAVIS: Is there a journal of sanitary engineering?

FELD: Oh, surely. There are any number on water pollution.

JOHNSTON: Storage of waste?

FELD: Disposal of solid waste is a rich subject, especially in this country.

JOHNSTON: Would these journals come to the attention of underdeveloped countries?

FELD: Oh, yes. And they are being translated into Russian too, and Chinese.

SALKIND: One of the most interesting possibilities, in my opinion, in connection with avoiding air pollution, is the use of treated water on the rivers for special agriculture.

FELD: Yes, of course.

SALKIND: As you know, experiments are going on. But as far as I know, there are no final results.

FELD: They do it in Japan. In the rice paddies the water is warmed by the sun and then recirculated through the root structure, and rice production is doubled.

SALKIND: But the crucial question is, What are the approaches that would profit from water at a higher temperature?

FELD: One thing that will happen is a longer growing season, because you can start your crops much earlier in the year if you use warm water for irrigation.

TROMP: In a city like New York, what do people do with plastic? In an incinerator it doesn't burn, of course.

FELD: The local apartment house incinerators in the City of New York are being eliminated right now.

TROMP: People who have plastic things in their home, what do they do with them when they are thrown out?

FELD: It is crushed by trucks, and sent to the city incinerators, which run at about 600 to 800°. That doesn't burn it. It develops into ash. The ash is accumulated on barges and towed out to marshland and used as "sanitary fill."

At the same time, we still have available land in Staten Island, the Arthur Kills area, for fill land. Then, of course, the Jersey Meadows are available.

KORFF: The Jersey Meadows, yes.

FELD: It may take three or four generations to fill in those and build land. Japan is doing a great deal of this, building land along the coast.

DAVIS: Have you run into trouble with the conservationists?

FELD: We have. You always run across the conservationists. They're against everything. I asked one, "How far back shall we go before we stop? Do you still want the telephone? All right, let's eliminate the telephone. Do you still want electricity? Do you still want steam? Or do you still want the wheel? How far back should we actually go?" Conservation, as it's now pictured through the Sierra Club and the Audubon Society, is a desire to go back to nature. How many people can nature take care of without the production of goods? I have always argued that the standard of living cannot be raised by ideas or ideals, only by the production of goods.

JOHNSTON: As a social scientist, I question that.

FELD: You do? Give a single instance in history, if you possibly can, when the standard of living was increased by anything but the production of goods. The desires of the people could have been increased.

JOHNSTON: Ideas are all-pervasive. You cannot produce anything without ideas. I think it's an artificial distinction, don't you?

DAVIS: In a natural ecology the population is limited only by starvation. If you wish to pursue the conservation ideal to the ultimate, you have to accept the fact that a certain percentage of your population will starve to death.

FELD: Well, they don't have to starve to death. They could be eaten.

DAVIS: Yes.

FELD: Or they could be killed.

DAVIS: That's the other way, of course, of increasing the standard of living, kill off part of the population.

FELD: If you want to read the best-balanced situation, you go back to about the 14th century and read the Chinese literature. The total economy was set by each province. So many areas of forest had to be left, so many areas of farmland, so many towns, always put on nonproductive land. And the population was fixed. If the population got too big, the rivers took care of the children. Female children were more expendable than male. And this lasted for many, many centuries in China.

NIGRELLI: But, you see, they were practicing conservation. What you're going to do is destroy the conservationists.

FELD: In what way?

NIGRELLI: By the environment, by modifying the environment.

FELD: I have to say that, to take care of a larger population with a higher standard of living than existed 100 years ago, we must modify the environment. But we have a limit to which we can go, a saturation point we must not exceed.

DAVIS: In the ultimate, we need a closed ecological cycle. We did quite a bit of experimentation and thinking on this in connection with the space program a number of years back, and we're still doing it. But if you're going to talk of extremely long voyages in space, like the Mars trip, you also are committed to an approximately or quasi-closed ecological cycle in which you reuse everything, and there are quite a few things you can do.

JOHNSTON: This assumes you want very substantial migrations of human beings to participate in your ecological system.

DAVIS: I'm just saying; take three men and send them away for four years, the attempt to carry enough supplies for them to exist for four years is ridiculous. They've got to grow food. They've got to recycle everything. Certainly their water has to be continuously recycled.

FELD: You don't even have to go that far. I was on the scientific advisory board of the Air Force during a tour of duty. One of the problems that we discussed at great length is the complete isolation of an air mission to an area beyond our control, military control, and preparing them for a complete, self-sufficient life for six months—housing, food, disposal of wastes—everything. Now, this is the same thing. It's balanced economy. We first estimate the requirements and then fit those requirements in on a one-mission, one-shot basis.

SALKIND: Then you are not much concerned about what happens to the area when the unit departs?

FELD: When the unit departs, the jungle will take it over.

DAVIS: In space, you do care. My point is only that I think some of the things that have been learned in that program could very well be applied to the earth as a whole—the recycling of water, for example, and the recycling of materials.

FELD: This change in the ecology has to take into account the locale, the area that you deal with. Just to give you one example, near the end of the Second World War, two airstrips were built in British Guiana on the shores of South America, the north shore, as part of the U-boat control mission. They were finished just about when the war ended. The U.S. Engineers sent out a team to evaluate all of these projects that were built outside the country and to determine payment to contractors. By the time they got to British Guiana, they couldn't find the airports. There were no signs. The jungle had covered them over. It was only by infrared photographs that the Air Force could locate them.

SALKIND: How long was it there?

FELD: Less than one year. I have been in Belém, on the Amazon River, a large city—a quarter of a million people—and if your house is at the end of the street, near the jungle, and you leave for the summer and don't have a caretaker, when you come back, three months later, you haven't got a house.

DAVIS: The exact opposite of that is the case of northern slope of Alaska, where trash is still there from World War II. There has been no corruption whatsoever.

KORFF: In the Antarctic, Captain Stark's original food cache is still intact.

FELD: That's right. So, you see, you must take the locale into consideration.

JOHNSTON: This introduces philosophical questions, because we are now asking ourselves how you divide self-sufficiency from interdependence. That's what we're talking about. Are we assuming that we all want to be self-sufficient up to a point as groups of people scattered throughout the world? Second, we all need to be interdependent up to a point. If so, at what points do we stop wanting to be self-sufficient, and do we start feeling that we have to be interdependent? It's a philosophical question.

FELD: Let me show you how interdependent we really are. During the Second World War, the United States made an estimate of where all of the strategic materials came from and how much was available. There were 72 strategic and critical materials. Only 40 of these were in sufficient supply in this country; for 32, the United States was dependent on imports from other countries, including Germany. And, believe it or not, during the entire Second World War those materials came from Germany through Turkey.

JOHNSTON: There's a theory among social scientists that the United States participated in the Korean War because it needed a certain mineral and 90 percent of the world's supply existed in Korea.

FELD: At international engineering meetings, outside the sessions, we have a tremendous number of political arguments. And I was quite shocked, four years ago, when a friend of mine from Poland was talking about the relations between Red China and Russia, and Red China and Poland, and Red China and the United States. He said that he was convinced that he could explain all the Red Chinese moves with this theory: Red China wants the United States to drop atomic bombs on Red China because they are trying to get rid of 300 million people to balance their ecology. They have too many people.

KORFF: After all, it's a well-known notion that all of the countries that have lost a war with the United States are definitely better off after they lost the war than before.

TROMP: Your point was that we could get a higher standard of living only by producing more goods.

FELD: Yes.

TROMP: It depends, of course, on how you define standard of living. Is it only that everyone has a television set?

FELD: I think standard of living can best be explained in a negative way. When you can survive by working fewer hours, you have increased your standard of living.

TROMP: Does that mean you're happier to work fewer hours? It may mean you're bored.

FELD: I'm not saying happy. You're working fewer hours.

DAVIS: Which is not necessarily an improvement.

TROMP: It is not necessarily a good thing, I agree with you.

KORFF: It will not necessarily lead to happiness.

FELD: That's right. I'm not saying it does. At the end of the war, I was asked to take a group of German industrialists around and show them certain industries. Finally we got around to the relative standard of living. We were on a construction job. I said, "Look, do you see that laborer? He gets about $3 an hour." I said, "He can buy 30 glasses of beer for one hour's work. How many glasses of beer can a German laborer buy from one hour's work?"

"Oh," they said, "you have a high standard of living."

TROMP: But still, if you take a city like New York, imagine people with less television and iceboxes, I think the standard of living of that one group would be healthier and maybe higher than if all the people had to live in high skyscrapers.

FELD: People in New York City don't live in high skyscrapers. This is a total misconception. As an example, ten years ago my office went through the entire real estate map of Manhattan Island and put on our computer the area of each building and the number of stories. What do you think was the geometric mean of height of buildings in Manhattan Island? Two to three stories.

DAVIS: Isn't it the real measure of a standard of living that you are free to

choose to live in the environment you wish? Is that a better indicator than a skyscraper?

FELD: Yes, but don't forget this: If I live 40 miles from New York City, I have to be able to earn my living without working ten hours a day or eight hours a day, because of my travel time. It is now cheaper to buy a house with a green space within commuting distance of New York City than to buy an apartment.

TROMP: New York is an exception. How about other cities?

DAVIS: Washington is not as bad.

FELD: Washington is not as bad yet.

TROMP: But in general, do people like to live in apartments in the United States?

DAVIS: I don't think we're that homogeneous.

TROMP: In the country you can have all your facilities, your shops, and everything else.

FELDS Oh, yes, but the facility to waste your spare time isn't there.

KORFF: All the other things, the activities of the city—

FELD: That's the important thing. The use of free time is now getting to be more important than the use of work time.

TROMP: Around Stockholm there are also such satellite cities, and they have all the facilities—cinema, theater, and all that.

FELD: And still they maintain high-speed transportation to Stockholm.

DAVIS: Not all Americans want to live in the city when their children are grown. I wouldn't be caught dead in the city at any age. I like the country. I still say that the real index of the standard of living is the ability to make that choice, the fact that I can afford an automobile or other transportation in order to live in the country and work in the city. I think a key point here is that I don't think anybody here is saying that the standard of living is in itself an object of social worth. It might be merely one factor in the evolution of people. If they happen to have a very low standard of living, then you must bring them up to an adequate standard.

FELD: If they want it.

DAVIS: It's not a good; it's an indicator.

FELD: The American Ambassador offered two million steel plowshares to India as a gift, and the Indian delegate thanked him very much and refused. This was too rapid a change in farming. It would put out of work five million families whose job each year is to make new wooden plowshares for the farmers.

DAVIS: We have been attempting to come up with a concept for something that you might call an environmental-quality index. You have indices of an economic nature such as the gross national product, standard of living, et cetera. We have been seeking a concept for something that you might call an environmental-quality index.

FELD: Well, there is that. There are publications listing the same criteria for different communities in the United States, the suburbs especially, and indexing them as to their relative position in the economic scale.

DAVIS: I don't mean economic. That's my point. We're trying to find an index of environmental quality which is not economic in nature. In other words, the level of pollution, the quality of the water, the noise level, to come up with an index so that we could make the President and the Congress aware,

on a year-to-year basis, of whether we were getting better or worse in an environmental sense.

JOHNSTON: I suggest this is a very interesting topic. It might actually become the subject of a proposal of our Working Group, the problem of establishing indicators of environmental quality.

FELD: This is definition, isn't it?

JOHNSTON: Elaboration rather than definition.

FELD: Isn't it true that if the question already has the answer implicit in it, there is no sense asking the question?

JOHNSTON: A lawyer couldn't possibly accept that position.

DAVIS: First you must list all the factors of environmental quality.

JOHNSTON: Exactly.

DAVIS: You need a quantitative measure. If you can't measure, it's useless.

JOHNSTON: It's useless, I agree. I think the truth is that mankind could waste an awful lot of time in the next two or three decades talking about measures for environmental protection without coming down to this crucial question of how we measure environmental quality.

DAVIS: Then you have a balance to make. You may have to make a choice between moving your environmental quality index forward and moving your economic indices forward. If you are going to develop a new region, the quality of the environment goes down temporarily. But you have something to compare it with, at least. You can compare the economic gain with the environmental loss and make preparations to return the index to its former level.

TROMP: But you can't have the same index for every area.

DAVIS: I can take a geographical area, but I also want to be able to have a national average.

FELD: What is good for certain areas is not good for New York.

DAVIS: I don't mean that. You may use different inputs for your index, but at least I can assess whether we're making net progress or net loss. The cost-of-living index is based on the price of a basket of certain items of food, housing, and so forth, and the index is published every month.

JOHNSTON: May I list once again what I think are some of the main areas for further discussion? Storage of waste, development of resources—which may be too large, but it's an important topic, obviously—antipollution measures, satellite survey of the earth's resources, a variety, perhaps, of communications problems in our context, such as interdisciplinary cooperation, training programs, and so on, and the problem of establishing indicators of environmental quality.

FELD: Rather than training, isn't it education?

NIGRELLI: It is also training.

FELD: Because education will bring in wants.

TROMP: We also need better cooperation between engineers, on the one hand, and the medical profession, on the other. In the present state of affairs, it is not true that you can get cooperation between medical scientists and the nonmedical groups. If there were such a goal, then perhaps you could.

FELD: I have been one of a team that has worked since 1958 to design and build a new hospital, a central hospital. We are not getting finished. Our biggest stumbling block has been working with medical staff. I have visited other hospitals in other cities to see how this was accomplished. Outside of Chicago I visited one hospital with the most modern equipment; and I was

rather pleased, though shocked, to find out that this whole new facility was in control of an engineer and his director.

DAVIS: Incidentally, in connection with these various themes, I suggest that something like this survey of earth resources not be a major theme in itself. It is, after all, only a tool.

NIGRELLI: It is a tool for surveying our resources.

DAVIS: Right. As a tool for a major topic here, which is cultivating resources.

NIGRELLI: Right.

DAVIS: I think education is a tool. I think we should keep a major focus on our principal theme and regard the others as means of achieving the end.

* * *

DAVIS: I think an extremely important point has been made, that eventually we must head toward a steady-state solution. In a steady state we probably do not even obtain minerals from granite. We obtain minerals by reusing the minerals. In other words, we must eventually head back to a closed cycle in time. I think the one thing we can do with the types of people who have been brought together is to identify goals, not necessarily means of achieving the goals, but at least to identify the goals. I don't think that it ought to be only general, because, as has been pointed out, many people have identified general goals. I think that we have to do more than that or we have wasted our energies. Perhaps we have to identify steady-state long-term goals, identify milestones in reaching those goals, and then perhaps leave the mechanisms of reaching the milestones to the professional society—the engineer and the specialist. But I think if we don't specify goals in a fairly specific manner, we have merely created another set of general statements.

TROMP: We are eight or nine people here. We would accept certain goals, but if we had an audience of 30 people, probably other goals would be set.

DAVIS: My experience is that goals are normally set by smaller numbers of people than this. In fact, large numbers of people seldom, if ever, come to specific conclusions, unless they are led by strong individuals who see to it that they do so. I think that one should not be bashful about the problem of coming up with specific suggestions. Without a starting point of a fairly definite nature, there is a tendency for nothing to happen.

JOHNSTON: I wonder if we might begin to talk about goals by discussing how long we think it would be before we can reach a steady-state solution.

DAVIS: I would take as a starting point the technological trend curves that one plots. All have a tendency to become asymptotic in approximately the year 2000. I concluded back in the 1950s by these curves that by the year 2000 the technological revolution would be at an end and we would now be in another phase of life. As my very good friend Mr. Colandro has said, "I was born the year the electric lightbulb was invented. I have lived to see man set foot on the moon." In a historical sense, this cannot be considered progress. It is a quantum jump. It is instantaneous change in historical perspective. What we are in the midst of is qualitatively different from any other experience the human race has had. Furthermore, it is a unique experience. It will happen only once. If we don't do the right things now, we will never have another opportunity to do so.

PERRIN: Unless we start again from the monkey, and so forth.

DAVIS: I don't think anybody should be bashful in expressing his ideas,

even if they're wrong. Because, if they're wrong, enough people will tell you. But if you don't have positive ideas, no action takes place. Assume that by the year 2000 we will have completed the technological revolution. We will know everything that's practicable in physical science, and we will understand the physical processes. By then we will perhaps be in the midst of the biological or the psychological or the sociological revolution. But I suspect that the physical-science revolution will be complete. So it's not unreasonable to look at the next 30 years as the framework of our goal setting. By the year 2000 we ought to be able to do, at least technically, most of the things we have discussed. Could we assume that by the year 2000 we have at least the technical capability to achieve the steady state?

PLATT: Let me support one curious point. The underdeveloped countries, because they don't have to go through all the earlier stages of development, are in fact catching up faster and faster. And from the time when Japan was opened up to the West, in the 1860s, to the time when Japan was the third naval power in the world, by 1914 or thereabouts, was about 50 years. From the time of the Russian Revolution to the time of Sputnik, when Russia was the leader in the space race, was about 40 years. From the time of the Chinese Revolution in '48 to the time of Chinese satellites, Chinese atomic bombs, and the Chinese synthesis of insulin, is about 20 years. My guess is that the least-developed countries in the world, with a strong development program such as we now know how to organize, can be brought into the level of leadership from this point within a time of the order of 15 or 20 years.

TROMP: I'm afraid I have to disagree with that, because Japan and China were countries with a long background of culture, long before we had any culture. And they had the potentiality to develop very quickly.

PLATT: Culture is not technology.

TROMP: But they had the mental capacity. They had philosophers. They had a background entirely different from some of the African countries or even a country like Indonesia. I doubt very much—and I've spent a great part of my life in these countries—whether in 30 years all the other countries could do this. I don't believe it.

PERRIN: China may contribute to the development of advanced technology. China's scientific principles were a gift from Russian physicists 12 years ago.

PLATT: That's going to happen with all of the underdeveloped countries. Principles will be given from the outside.

PERRIN: This will give military power. But it hasn't changed the standard of living of the Chinese peasant, and this always takes much longer.

TROMP: This is a great problem in developing countries. People, because of their religious habits, aren't willing to accept this, even if experts went in, even if you come with material. The problem is to have them really accept this.

PLATT: I know what you're saying, and I know this is the conventional wisdom. I'm suggesting only that there may be forces in the world that will speed these processes up. To give an example, last year in the United States more than half the cattle were inseminated artificially. Last year in Kenya more than half the cattle were inseminated artificially. These developments travel with the speed of light.

PERRIN: Not in such a large community as India. Kenya is a small country; there is a small number of people, a small number of cars. But to introduce this in India is going to take 20 years.

PLATT: Sometimes I hear people say that because a country is large it

goes fast. This is the first time I have heard someone say that because a country is small it goes fast.

PERRIN: It is impossible, with a population of a few million, to really do the work for a population of 500 million.

TROMP: Don't forget, Kenya has a long experience through British colonization, whether they like it or not.

PLATT: This comes in from the outside. I didn't say it was self-generated. The point is that the world is now an intercommunication system in which these new developments will leap borders and the time for development will be shorter than it has even been in the past.

DAVIS: Whether we like it or not, we are going to learn to think as terrestrials in the next 30 years. We will be forced by our own technology and our own waste products to do so. When I said that the technological revolution would end in the year 2000, I also said that this was a question of an asymptote, and I'm speaking statistically. This does not mean that it will have taken place everywhere and be totally complete. It means merely it will be up to the point where, let's say, 95 percent is complete and the remaining 5 percent may take a thousand years.

TROMP: So many other factors could come in which could change your asymptote.

DAVIS: As Mr. Heinlein pointed out, the day that man set foot on the moon, 80 percent of the population of the world was still using outside plumbing, so that there is a great discrepancy. But I think 30 years from now we will have the capability at least to monitor a closed-cycle environment. We may not do this, we may not have achieved the political capability to do it or the social capability, but I think we will have achieved the technological capability.

TROMP: The next point is the problem of storage of waste.

PLATT; Why should waste be stored? That's absurd.

PERRIN: There is always a part of the waste that cannot be used.

PLATT: It came from the earth. It can return to the earth.

PERRIN: Yes, of course. But this is a question of final dumping of some kinds of waste.

PLATT: Which came from a dump in the beginning.

PERRIN: Yes, but here again is the question: Are we ready to pay for it? We are ready to bring coal to a large city like New York from Pennsylvania. We are not ready to bring the ashes resulting from the combustion of this coal back to Pennsylvania.

PLATT: They could be brought in the same cars. They have to go back anyway.

PERRIN: Yes, yes, it should be done, but until now it hasn't been done. And this is a point that should be emphasized, that the final disposal of waste shouldn't be a problem for mankind, but we have to pay for it.

PLATT: In fact, it is cheaper than what we are doing now. We are now paying for it, but we are paying very expensively. We are paying in lung disease. We're already paying for it, except we're paying inefficiently and by a bad system. It would be cheaper to send it back.

PERRIN: It's a question of political organization, of political decision.

PLATT: It's a question of switching from the public sector to the private sector, but it is not a question of cost.

PERRIN: No. It's a question of shifting from the private sector to the public sector. The public should pay for this.

DAVIS: Don't we have again the two-stage question? In the closed cycle that we take as an ultimate goal, there is no final storage of waste. In the interim, as intermediate milestones, there will be eras, episodes, when it will be necessary to store waste until it is economically useful or possible to do something with it. So, it's more interim storage than a final storage. The day will come, I'm quite sure, when we will recycle everything; but in the interim we still have to dispose of large numbers of finished automobiles and tires and other wastes.

TROMP: Do you have any proposal for storing plastic, which is quite a problem?

PLATT: Plastics have been synthesized in factories. They could be resynthesized.

PERRIN: That would be very expensive. It should be done, but in the form of hydrochloric acid.

PLATT: Let me give an example. There is a certain chemical company to which a friend of mine is an adviser. The company was considering a new type of plastic that would be more difficult to dispose of than the old but cheaper to manufacture. So the man said, "You know, this company should be taxed if they made such a plastic because of the cost to dispose of it." He almost lost his job. He has proposed a negative reinforcement. No complex organization can be built by negative reinforcement. The only way to build a complex system is by positive reinforcements. What he should have said is, "It will save the community money if we make more-disposable plastics." Therefore, our legislatures should pay some fraction of the cost of garbage disposal as a bonus for five years to any company that will design an improved, more-disposable plastic. The legislation will save money, because the garbage disposal is less. The company will have a positive reward because it is offered a bonus for a development project. And, in the long run, the community will benefit. In short, you are transforming a negative reinforcement to a positive reinforcement, and suddenly the thing becomes easy, simple, and is done.

PERRIN: We see the same thing in the question of detergents. There should be laws forbidding the large-scale use of detergents that are not biologically destructible. This is the only way to avoid the enormous amount of foam in all our rivers. There should be money spent in research for this. Eventually there must be a regulation forbidding the use—or, before forbidding, maybe by taxing.

PLATT: Actually, it was done voluntarily by private enterprise in this country. What we need is economic imagination.

PERRIN: Yes, but that is for a country to adopt. I'm sure that we must consider that eventually detergents that are not biodegradable should be forbidden. High-octane gasoline with lead should be forbidden. Meanwhile, I think taxes should be put on high-octane gasoline containing lead.

PLATT: This is an amusing irony. For 40 years the Americans have been paying two cents extra per gallon in order to have lead in their gasoline. Now they are told they must pay four cents extra for lead-free gasoline.

PERRIN: It is more expensive to have good gasoline, high-octane gasoline, without lead. That's why it has not developed until now. You must have a regulation or a tax on lead-containing gasoline.

PLATT: When you look at these problems from a systems point of view and from the point of view of the positive advantages to the total community of making a better system, you see that it is, in fact, cheaper, and all that is needed is economic imagination to encourage these future benefits with present motivation.

DAVIS: I like the suggestion that was made as an example of storage of compacting automobiles and other metallic wastes and burying them in the empty strip mines of Pennsylvania and saving them as iron ore for the future. Reclamation may not be economically feasible today. It's very likely that within our 30-year period it will be economically feasible. When and if it becomes so, there will be a supply in a concentrated spot.

HUGO BOYKO: The problem of water pollution can be solved. This is a matter of scientific results acquired in the last few years and applied in several countries quite successfully and inexpensively. Industrial wastes, sewage from cities, and agricultural wastes can be purified, as in nature, by higher plants. This is completely new. Up to now, the main difference has been that the animal has to take up organic compounds and the plant has to take up inorganic compounds. But this is not completely true. Higher plants—specific plants, not all—are able to take up many mineral poisons, compounds that are poisons for other plants, such as sodium chloride, and organic compounds such as those that are components of polluted water. In addition, these plants are able to kill the pathogens, microorganisms in the water, and very quickly.

In nature this process takes place along a stream. Where there is such vegetation, the water will be much cleaner than before. This is partly the work of the higher plants and partly the work of microorganisms. Microorganisms, however, offer little resistance to change in the environment. Temperature or pH changes immediately eliminate a whole group of microorganisms, and they can't work like the higher plants, which are much tougher. Now, ways have been found, in Israel and in the Max Planck Institute in Germany, to coordinate cooperation between the Max Planck Institute, the University of Göttingen, and certain institutes of higher learning in the United States, as a start for a world task force. We will have the cooperation of an association of engineers. The physical sciences, without the engineers, are not enough. I have also been invited to Washington to speak about this with some people responsible in the area of pollution.

In my opinion, this is only an example of how, with very little money, a big program can be started. At the moment, the first great success is to be seen in several places in Israel. Then big money, which is necessary, of course, will come in. I am convinced of this. I have seen such cases already in Holland, in Israel, in Czechoslovakia, in Germany, and in Argentina. The main thing is that it is possible to tackle not only this problem but also many other problems by such small beginnings on the part of really competent institutions and to enlarge the endeavor in the course of a few years to a real world task force. I am doing this with these two problems: pollution of water and desert reclamation. In both these fields the start has already been made. At the moment it is only a very small thing, but for desert reclamation we already have a pilot plant and $500,000, and it has worked very successfully.

There should be a recommendation that wherever it is possible such starts should be made to organize a task force on a transnational basis. Science is the only transnational body up to now, and science as such can create such a transnational organization and world task force without interference from political powers. This is the only field where this is possible. Of course, the centers can be here in America and in Europe and partly in the small country Israel, but the outcome will be for the whole world. I think this should be in the form of a resolution.

PLATT: About the plants that kill bacteria: do they do this by specific poisons that affect specific strains of bacteria?

HUGO BOYKO: They are exuding bactericides.

PLATT: There are particular compounds that can be synthesized.

HUGO BOYKO: It is only two or three years since the biochemical problem was solved by Dr. Kickuth in Göttingen. This is the first time the biochemical approach has been made to these problems, and he is part of this cooperating network. We hope that more will cooperate with this.

ELISABETH BOYKO: The idea was that the plant works in cooperation with microorganisms that do part of the work, but he has been able to prove that, in 33 sterile conditions where no microorganisms were present, the root system of the plant is the active part without any additional cooperation of microorganisms. The activity is solely the action of the root system and the way in which the water is fed to these root plants in a slow stream that can be purified and converted from sewage water to pure water.

PLATT: This is done by aeration, by oxygen, in a sewage disposal system, or by chlorination. Are these processes cheaper than aeration or chlorination?

ELISABETH BOYKO: Not only cheaper but more effective. We have seen, after chlorination, after the chemical processes, a stinking pool. I've seen the water processed, and when it was ready to go into one of the lakes, it was still something neither of us would have waded in.

PLATT: So, you would recommend that these bactericide compounds be identified and synthesized, and then used on a large scale for water purification.

HUGO BOYKO: I think the use of plants is much cheaper.

TROMP: There are two processes. One is the bacterial one. In the second, the toxic substances are absorbed and broken down. So, even if you have put an antibacterial compound into the water, it is not the only agent, because the plants seem to be able to absorb toxic substances and break them down.

PLATT: Any biochemical system breaks down enormous numbers of compounds. I'm not sure of the advantage with plants as compared with other bacterial systems.

HUGO BOYKO: There is a lot of scientific literature available, and I shall try to give this literature to everybody interested.

PERRIN: I would think that such purification by cultivation of special plants might be cheaper for small purification plants and small communities. We have a great problem in France, for instance, in purification of waste water from small communities, and this might be a cheaper way of purification than using a special plant with chemicals. I think it should be worked out—the best way to organize purification of water for villages or small communities.

HUGO BOYKO: And small industries.

PERRIN: Small industries. They are much worried by the pollution of water and seashore, for instance.

HUGO BOYKO: In Berlin, for example, there is purification of sewage water. In Lindau there is the same. But in Lindau there is a normal purification plant,

and in addition to this there are 25 square meters with only these plants, and the water emerges much cleaner than before.

ELISABETH BOYKO: In a Dutch resort of 5,000 people, the sewage water flowed into a planted one-acre area that had been constructed specifically for purifying the sewage water and getting rid of it so that it didn't infest the whole area. It came out as clear as drinking water.

DAVIS: It seems to me that this is a tremendously exciting development. In a way, if the technological physical-science revolution has 30 years to work and is near its end, I think we're just at the very beginning of the next cycle, which might very well be a biological or bioecological revolution. Here is something that has been called biological engineering or ecological engineering, which has as its ultimate objectives the creation of a benevolent ecological cycle. And if you can do this by, if you like, teaching the plants to do it for you, you gain an advantage in addition to purification. You are also reprocessing carbon dioxide into oxygen. You are helping maintain the balance between oxygen and carbon dioxide. The larger the scale you do this on, the better off you are. I find this very exciting, and it seems to me this is the kind of area that is deserving of the greatest kind of support.

HUGO BOYKO: These purification plantations must be decentralized because they need large areas for the plants.

ELISABETH BOYKO: A specific amount of water requires a specific size of plantation in order to work. In a big town you have to have several outlets and sufficient space to put up each plantation in order to clean off the waste water before it goes into the streams.

HUGO BOYKO: It's all right for 100,000 people.

FELD: How would you do it for the city of New York?

ELISABETH BOYKO: The city of New York wouldn't make this big jump yet.

FELD: The city of New York has 18 plants to take care of the whole population for the control of water wastes. The plants in New York City, and this is true of other large cities, occupy one half of one percent of the populated area that is being taken care of. The sewage from, say, 1,000 acres requires a plant that is one half of one percent of 1,000, which is 5 acres. This is pretty close to the minimum, using the most expensive type of construction.

The costs of the plants in New York City—and more are now under construction or being improved—is in the range of $2 billion. They remove about 90 percent of the BOD requirement and allow the water to be sent into the different estuary rivers without affecting the ecology.

PLATT: This is in the range of a capital investment of $20 per person per year.

DAVIS: Why do you necessarily want the minimum space? Why not have large parks in the city? Why not make an object of beauty out of your sewage disposal facilities?

FELD: When I say one half of one percent for a sewage disposal plant, the type that you are describing would require areas probably in excess of the total area of New York City.

SHEDLOVSKY: There is no question in my mind that for certain communities, as Dr. Perrin has mentioned, this is a good idea. The fact that it isn't a good idea for New York—I could tell you all sorts of things about New York that are not very good.

ELISABETH BOYKO: It doesn't attempt to solve the whole complexity of the question. We haven't come to the dimensions of New York and to the problems of New York. The problems are coming up as these countries gradually grow and develop their land and are faced with these problems.

PERRIN: I would like to know if purification of water by cultivation of plants is effective throughout the year.

HUGO BOYKO: There are a few plants that are effective in winter and some in summer. We have different plants for different regions.

TROMP: Temperature regions.

HUGO BOYKO: For all places in different climates, et cetera, it is a matter of only a few months to find out which plants or which mixture of plants should be used. For the engineers, we must determine the speed at which the water has to go through the roots, and the inclination of the stream through these plants. That is a matter of experiment that can be made in a laboratory in a few weeks. To make the plants apply on a larger scale, I wouldn't advise starting with New York. But on the basis of 10, 50, 100 smaller places, what to do or how to do it, can be determined. The camping plantation, for instance, used a 2-kilometer pipeline from the camping place to the plantation. The sewage water was pumped to the center of the plantation, and from the corners of the plantation pure drinking water came out. Maybe better engineering methods in other places could be adapted to the local conditions. But the principle is already proved, and it is excellent and inexpensive.

TROMP: Are these plants very resistant to plant diseases? If the whole plantation died, you would have no water purification.

HUGO BOYKO: Only the seedlings, very young plants, are very sensitive.

TROMP: What would extreme cold or extreme heat do?

HUGO BOYKO: I can give you the answer for specific bases, but you have to discuss this with the engineers.

TROMP: Do you agree that we make a general statement about more support to biological research such as in the studies by Dr. Boyko?

DAVIS: Yes. I would suggest we set a long-range goal, such as a benevolent ecology. I think that our ideal, our goal, is a benevolent ecology with man included in the cycle, both his mind and his body. I think we must make an optimal combination of physical and biological techniques to achieve this ecology. I think that we could identify the areas that are important for research and specifically include those developing new biological systems that would aid in achieving the long-term goal.

FELD: I was doing some work in Anchorage, Alaska, and the scheme would not work in that climate. One of the greatest difficulties up there is disposal of wastes, because of the temperature of the soil.

HUGO BOYKO: It's the solid wastes you mean?

FELD: The liquid wastes or the solid wastes. To give you an instance, the ice along the waterfront builds up to thicknesses of 20 feet—7 meters—each winter, in Anchorage.

HUGO BOYKO: In that period of time any disposal system is hopeless. This is one of those endeavors that could be tried out for such regions. There are plants of this group that are able to do this for various regions. But we have to try out which is the best one.

FELD: You think the plant will maintain a liquid phase?

HUGO BOYKO: If there's no fluid, if it's frozen, it will not work.

FELD: You mean by adding fluid you can still maintain a liquid phase?

ELISABETH BOYKO: No, of course not. If the whole area is frozen, then of course there is no flow. If there is no flow, there is no activity. This system is for certain areas that are threatened with pollution danger, not for all.

FELD: We have that in the New York area certainly. We have it in Alaska, to my knowledge. We also have it in the extremely hot climate and the high humidity of Central Brazil. The flow of rain and water is so rapid that the pollution doesn't dissipate.

ELISABETH BOYKO: Then you have to create a slow flow before it goes into the quick flowing.

HUGO BOYKO: In Alaska if you want fluid, then you must—

ELISABETH BOYKO: Make a kind of hothouse.

FELD: This is being considered, yes.

CUNETTA: Water pollution control has to be related to a particular water-quality criterion. We have it within our means now to make drinking water out of raw sewage. It all goes back to money; we have the techniques.

HUGO BOYKO: Work in this line has to be scientific, and it has to be supported, with scientists making experiments in any region, in any place, in order to find specific solutions.

TROMP: Let's go on to the policy implications of satellite survey of earth resources.

DAVIS: I tried to make the point earlier that the satellite survey is a tool rather than an objective *per se*. I think what is significant is that within ten years we will have the capability for more or less continuous monitoring of the earth's surface, water, atmosphere, and immediate outer space. We will have the capability at least to measure the parameters of the physical environment and to an extent the biological, agricultural growth, the forests, et cetera. I believe that this is a factor that should be taken into consideration in long-term planning. It means that a tool will exist for feedback into the management of the total environment.

It should be a factor in our considerations for the next 30 years and for the next decade. It also raises many policy questions having to do with international relationships and sovereignty and will undoubtedly raise many institutional questions for the future. The institutional questions are already being worried about to an extent within the United Nations and various other international groups. I believe we have convinced ourselves that we can identify plant species, at least significant plant species. We can tell something about the health of the species, insect infestation, plant disease, excess salinity, drought, and many other factors. We can tell something about soil and water, soil moisture. This will have implications for long-range prediction, but it is even more important to identify what is there now. Oddly enough, it is very difficult to determine that you are having drought until it is too late to do anything about it.

I think we will improve our understanding of the interrelationships between solar events and atmospheric events and in general be able to look at the atmosphere and its boundaries, both upper and lower. We will be able to observe earth-axis movements and the correlation of those with seismic events: there appears to be such a correlation. We will be able to observe the general circulation of the oceans on a global basis, both from thermal measurements and measurements of the height of the geoid or equipotential surface. We will also be able to identify the main geological formations and, to an extent, rock types where earth surface rocks are exposed. We can classify soils, types

of land, types of plants, and probably also identify areas of probable location of fish or at least regions that would normally attract fish, both by chlorophyll content in the water and by the thermal discontinuities of the water.

We also have plans to relay data from remote locations, such as the oceans, through buoys and remote seismometers, so that we can rapidly identify seismic sea waves, for example, and warn of their attack. We will probably have a greatly increased capability to predict and warn of severe storms, hurricanes, and the like. The system will also provide a necessary input or feedback, should we ever consider major, large-scale weather modification.

TROMP: What recommendations would help?

DAVIS: The only significant point is that here is a potential tool for the monitoring of the environment, for the creation of information on the basis of which management decisions can be made, and I wouldn't wish to imply any more. I think that in our deliberations we should recognize, if possible, the value of such a tool, or the impending value.

JOHNSTON: Would the international scientific community not be interested in considering a proposal that there be a method of appraising the uses of these satellites for scientific purposes from time to time, not necessarily on a permanent basis?

DAVIS: I think there are both national and international activities in process to do so. It is very difficult at this stage, because this is an experiment; it is not a prototype; it is not in any sense an operational system. I don't think that we wish to strain the experiment as such, but even in the experimental phase we have deliberately involved other nations on the basis of their own interest, more or less opportunistically, because they happen to be interested and we happen to be interested in somebody to work with. At the moment, Brazil, Mexico, and Argentina are in communication with us and are assisting us in the evaluation of these techniques with regard to their own problems. One rather obvious problem is the creation of maps. One of the most important things in an underdeveloped territory is a map, and even a map based on a resolution of 400 feet is a lot better than anything heretofore known in some countries.

JOHNSTON: In the view of the international scientific community what should be, at some time in the future, the procedures for appraising the results of such a future program? How can we be sure that decisions made for such a system are for the maximum benefit of everybody in the world?

DAVIS: We're trying to take steps to do this. For example, I'm going to make a presentation, I hope, at the International Astronautical Federation, where there will be a session on the earth resources satellites. There have been other presentations. We are very reluctant to attempt to identify operational systems or to create expectations that cannot be fulfilled. This is one reason we're being so conservative. It is not a disinclination to involve international thinking. What we're trying to avoid is too many expectations.

JOHNSTON: But surely if it proves difficult within one country for financial reasons to maintain this adequately, then there will be all the more reasons we should consider it from an international point of view.

DAVIS: It is our intention to expose this to the international community. As you know, the President has already announced that this will be done. There will be U.N. meetings of other organizations on earth resources. We have discussed the possibility of a United Nations-operated data center. Our State Department has been involved as well.

JOHNSTON: Would this not be an appropriate time and place for international scientists to acclaim the contributions now being made through this system and express the hope that it would become permanent as an international program at some later date? In the meantime, looking to this future, we might emphasize that it's too important a work to be allowed to be discontinued and that there should be international processes for appraising such programs.

PERRIN: How could we advise the American Government to spend its own money?

JOHNSTON: An expression of great pleasure on the part of international scientists must be a source of satisfaction to the American Government.

PERRIN: Especially if it is for the best use of the world community.

JOHNSTON: We also put the international community on notice that if any one national government should be unable to maintain this on a permanent basis, then it is the responsibility of the international community to finance it.

PERRIN: Where will the money come from?

JOHNSTON: This is not our concern. At a certain point we stop. I am suggesting that certain aspirations could be expressed and concern could be registered, a degree of interest.

TROMP: Is most of your material in this field classified?

DAVIS: Not as far as I know.

TROMP: So it will appear in scientific journals?

DAVIS: Absolutely; the experimental data are freely available internationally.

TROMP: I would like to move to the problems of communication. The first one is interdisciplinary cooperation and overspecialization.

DAVIS: I think the communication between science and engineering and management and/or government is extremely important. It's not only between the disciplines of science. It's between the scientists and the technologists and the technologists and the user. I think there is a multidimensional aspect to this problem.

PERRIN: I think we should not speak of overspecialization but just presentation. It's not because the fields in which one works or is trained are much more narrow than before. This is not what is in question. All students in science should have some general teaching or information in social science, for instance. It's not that we have overspecialization in the field of science training that is the problem. And vice versa: I think that all students, whether they are studying law or humanities, should have some broad information about science and a general consideration about what science is, not because they specialize in international law or Roman law.

TROMP: A broader, basic interdisciplinary program.

PERRIN: Yes. I think this is essential.

DAVIS: I'd like to suggest that the World Academy is almost in a unique position to do this. I would say that a recommendation could be made to the Academy to act as a focus for taking the initiative in interdisciplinary activity. It's particularly important because it's not just the World Academy of Science —it's Art *and* Science. I think it would be a useful focal point. All the other organizations tend to be either narrowly or broadly specialized in science.

JOHNSTON: I suspect that these points have been made in every one of the working groups; we should try to narrow our recommendations, if any, to the particular field of earth sciences and resource cultivation.

DAVIS: There is a need on the part of scientists to recognize that, at this stage of world history at least—they must be willing to focus on objectives external to their own discipline. The same would apply to lawyers, engineers. I think in every learning specialty, every discipline, one must recognize the need to look at objectives external to his discipline.

HUGO BOYKO: The word "art" was used to expand the possibility of contributions from all fields.

JOHNSTON: Are there any specific examples?

DAVIS: A very trivial one, a very obvious one, is the general field of environmental pollution. I represent an agency that has a charter to describe and forecast the physical environment. We are not permitted to concern ourselves with the biological environment. For example, we provide the New York air-pollution people with meteorological forecasts. We'll tell them when there will be a pollution potential. We are not permitted, however, to forecast pollution, because pollution is the responsibility of the Department of Health, Education, and Welfare. They, on the other hand, are not meteorologists.

It is impossible to treat the problem of air pollution without perhaps creating, let's say, water pollution in the process. But water pollution is the responsibility of the Federal Water Pollution Control Agency, which is in the Department of Interior, and we are not permitted to concern ourselves with that. Similarly, we can chart the coasts of the United States, the continental shelf, but we are not permitted to deal with resources, because resources is a function of the Department of Interior.

Within our own government we are a complete mess. There is no single agency that has a responsibility to approach the problem. Each man says, "I can't do that. My job is only to make the weather forecast. My job is only to identify the resource. My job is only to count the pollutants in the air." As a result of the institutions, people tend to study what the institutions hire. They will hire meteorologists and they will hire oceanographers. The schools will not produce a meteoro-oceanographer because there's no market for him. So, the institutional changes sometimes create a market for a discipline.

SALKIND: How about a National Academy of Sciences? There is such a thing?

FELD: That's the purpose of it.

DAVIS: My experience with such institutions, including the Air Force Scientific Advisory Board, has been that they still tend to advise within their specialties, within their disciplinary frame of reference.

FIONANDA: I was thinking of what was being said in the main session, that there is really a possibility for this conference to make an explicit statement about the high value of interdisciplinarity. I think this group should make a concise statement, because perhaps everyone expects someone else to do it. It could perhaps state that the conference encourages all experimentation along the lines of interdisciplinary research and encourages institutions to take up such experimentation. There should be an open attitude toward interdisciplinary experimentation.

JOHNSTON: I think we could try to spell out more specifically certain scientific organizations by name, scientific disciplines, that could be asked by the World Academy to enter into some kind of meaningful collaboration and cooperation with other specified, named organizations.

FELD: I think the International Geophysical Year would give you an

example of some of them. Everybody pitched in on a problem for 18 months and did a good job tying together all possible disciplines.

DAVIS: This is being done, for example, today in a place like Antarctica. There's such a small number of people that the seismologist has to help hold the balloon for the meteorologist. I think it's a social problem. I think the biggest social problem of all is that the interdisciplinarian is regarded by the specialist as a dilettante.

FELD: And vice versa.

DAVIS: Warren McCulloch once outlined how to make a generalist. His recipe was that you should study mathematics and languages first—languages because that gave you the practice of transferring an idea from one frame of reference to another, and mathematics because that's a more or less universal tool. Then get a Ph.D. in something, anything, because you must have the self-discipline to achieve a degree of excellence in something, and then go to work in a field that is completely new to you. Then you will begin to be a generalist.

* * *

TROMP: Problems of Communication had three topics: Interdisciplinary Cooperation, Educational Training Program, and Problems of Underdeveloped Countries.

JOHNSTON: I thought that it might be useful to be as specific as possible about the kind of organizations that should be persuaded to come together more often—at least that was one point, specificity would be helpful.

DAVIS: I'd like to suggest that we not limit this topic to the different scientific disciplines or even social scientific disciplines, that in fact one of the things we've got to consider here is publication.

TROMP: There is a tendency not to solve urgent problems by interdisciplinary contacts, and it's very rare to find good interdisciplinary contacts.

DAVIS: A general area that bothers me is communication between scientists in general and the rest of the world. Because of long traditions in science, there is a reluctance to focus research on problems. There is a tendency to focus research on science, if you like; and then if somebody later applies the results to a problem, that's fine, but it's somewhat lower-class. This is a key problem that we've got to face sooner or later—how to convince scientists in general that it is worthwhile, appropriate and proper, and dignified and professional to turn outward from their discipline to concentrate on other problems.

KORFF: There are two aspects to this really. One is to say that engineering developments that follow scientific work are also important. And the second is the whole problem of public relations of science, because there seems to be no doubt at all that science in the last few years has had incredibly bad public relations. I have overheard students in the halls of our university say that all physicists ever think about is how to kill people. It's an impression that, unfortunately, physicists have done nothing to dispel. It could be dispelled quite easily by simply telling the truth. But this myth has been built up and is part of the whole problem of the very bad public relations that science has at the present time. This is one of the reasons why there is so little money being offered in science at the present time.

DAVIS: There's a related reason. I went to a meeting at the National Academy at which we discussed the state of physics, and it was quite clear that everybody else regards physics as nuclear physics or atomic physics. I

was concerned with physics of the environment. There are not enough people, for example, in fluid mechanics of large systems. There are far too many people who have worked on subnuclear particles. How do we start a new trend to make physics and chemistry and biology and other scientific studies function in the context of environmental problems and become considered an appropriate and academic and scholarly and professional field for research? How do we make environmental science a proper professional sphere of inquiry for scientists?

JOHNSTON: There is an opportunity in other areas to combine and collaborate across this relatively acute division among scientists on broad questions of environmental needs.

DAVIS: We have lots of good physicists working on the upper atmosphere, down to 40 kilometers. At 40 kilometers there's an absolute barrier between engineering and science, between fluid mechanics and radar, a complete barrier.

NIGRELLI: The idea that scientists can solve our environmental problems, at least among political groups, is through. What we need now is for the engineers to come in and take all the basic information that science has already accumulated and translate it into some effective program.

DAVIS: That's one reason why we want to identify specific areas of research, because a lot of people don't realize that we do not know very much about the physics of the environment. It seems as though we should, but we don't. Robert Millikan said to me once when I was complaining about all the engineering you had to do in order to do research, "I learned a long time ago that an engineer is a physicist with a job."

TROMP: The next point was the education and training program.

JOHNSTON: In looking forward to the '70s, '80s, and '90s, are we satisfied with the present compartmentalization in science from the point of view of improving the world environment? A new kind of scientist ought to be created—a totally new kind of scientific work. This is a very large question, but we haven't talked about this at all. Specifically in North America, for example, it has been questioned whether it's feasible to have a B.A. course or B.Sc. course or some other kind of first-level course in college in four years that would expose a student to many or all aspects of environmental problems before he gets a master's or doctor's degree in one chosen discipline. So that it's guaranteed that if he comes out as a physicist, he will be an environment-oriented physicist. If he comes out as a lawyer later on, he will be an environment-oriented lawyer.

DAVIS: I think there's a danger in interdisciplinary education. If you're not very careful, you may produce dilettantes. It's not enough to have peripheral knowledge of many things. It is necessary but not sufficient to have a peripheral knowledge of many things. You put in a course in environmental science in the sophomore year and cover a bit of geology and biology and so forth. You would give the physicist a broader spectrum than he would get from merely one outside specialty. It would also be useful if we could make some attempt to influence the individual discipline. I can speak only of physics, to get students to recognize that there are important branches of physics other than high-energy physics and atomic physics, to identify the particular specialties that the disciplines should devote more attention to, such as the fluid mechanics of large fluid systems or the chemistry of large multiphase systems.

TROMP: Some of the other things they should know about are sociology and economics, not only scientific subjects.

KORFF: University administrations would be reluctant to put in any

additional requirements, because the students are already overloaded with required things, and the tendency is to allow them to take more voluntary, optional subjects rather than forcing them to take more required courses. The second point is that the more requirements you put into a curriculum, the more that curriculum becomes hidebound and unable to change. It becomes crystallized and unable to adapt itself to changing conditions. This has been a very serious problem with the engineering students at the present time. The engineering students have to specialize in a branch of engineering, start very early in making the choice of branch almost before they know what it's all about. Then they take a prescribed sequence of courses. At the end of that time they know how that part of engineering was practiced 30 years ago.

Ultimately, you have to think of the employability of those you are educating; what are you trying to educate them to do; what sorts of jobs do you envision they will have? At least in formulating the curriculum, you have to think a little about where the whole thing is going so that you can begin to set the dimensions. One guideline is to minimize, rather than maximize the obligatory requirements.

TROMP: I thought there was a tendency, at least in our part of the world, not to have overspecialization start so early. I don't think it's a good thing to have to decide in the first year whether one is going to be a mechanical engineer or an airplane engineer.

KORFF: When a student decides he's going to be a mechanical engineer, he drops all other forms of engineering and specializes in that branch.

TROMP: Isn't there also a tendency here to make his decision late?

KORFF: This is the direction we are all trying to push into, and this direction is firmly resisted by the professionals within the particular departments, because the professionals within the particular departments always say, "Well, he couldn't be a good mechanical engineer if he doesn't know how to draw a beautiful nut and bolt which is 100 percent accurate," et cetera.

TROMP: The point is whether we should accept that viewpoint or not.

KORFF: I agree that the crystallized viewpoint has built into it nonadaptability, and this is not a good thing. Ultimately it would be much better to give more flexible education to engineers and physicists so that they would be able to work in more diverse fields, because certainly nobody can predict today what any of these fields are going to look like 30 years from now. One of the difficulties is that these fields get more and more complex but the total number of hours a student can devote to study remains constant. There must be parts that he doesn't know. In physics today almost nobody studies acoustics, or acoustics is covered in the sophomore year in two lectures, and that's the end of it. Yet, if somebody wants to be an acoustical engineer, he will have to go into it and spend his whole life in it.

One by one the different parts of physics have been shed because of the increase in specialization and because the body of knowledge is expending exponentially. This is almost a problem that makes necessary continual revision of the curriculum and reconsideration of the problem of just where you're going and what you're trying to accomplish.

TROMP: I think one should be satisfied to specialize later on. I think students will never find the time later on to go into the general background.

JOHNSTON: There is a built-in inflexibility in any program. I wonder if you might add to the comments that we should make use of the activism among students who identify with social problems, such as the threat to the environment. What I have in mind is a recommendation by the World Academy to a foundation, perhaps, to provide grants for the specific purpose of loosening the built-in inflexibility and in this way provide advanced graduate students with total freedom to move around their region, to discover for themselves by interfering, as it were, with public agencies when they sense an environmental danger and by interference discover a research topic, a dissertation topic, for themselves. I understand that the new inquiry in Canada over the mercury content in Lake Erie was initiated by a research student at the University of Western Ontario who was looking for a dissertation topic and almost by accident stumbled across this subject. It seems ridiculous that it should be such a fortuitous matter. Wouldn't it be wise to set up a grant system so that other students could do this, would actually be encouraged to do this?

DAVIS: I think that story is probably somewhat apocryphal. Every now and then a graduate student will come to see us who has suddenly discovered something we've been working on for the last 15 years, but to him it's new, plus "you're incompetent," too.

I think there's another dimension to the problem. I think the way engineers are taught physics is most unfortunate. They usually use a nice book called Engineering Physics or something, in which they run through nice equations, and from there on, for ever, these become the basic tools of the engineer. What the engineer is never told is that these equations are empirical abstractions of more profound thoughts and that in fact the relationship is not really that precise in the real world and these laws are not really quite that solvent; with more than 2,000 cycles, for example, in a vibrating body there is nothing in the laws of physics as we know them that apply—it's impossible; the world turns to jello. In many, many areas you find engineers who use St. Venant's Equation in trying to compute transsonic flow. They will not question the basic engineering equations. We are, on the one hand, giving them a disrespect for physics because it is an inexact science or, on the other hand, convincing them that these equations are absolute. This part of the problem is a serious one. It tends to lead to doctrinaire positions.

AGLION: I wonder if we could recommend that courses in basic principles of conservation be given at all ages, starting very early.

KORFF: The difficulty is that you immediately find yourself in a competitive situation. You're competing with all other courses. For example, certainly in the public schools today nobody learns any geography.

JOHNSTON: This is a point we could make, that geography is a neglected subject in the public schools; and for environmental reasons it ought to be re-emphasized.

KORFF: This may be a good reason for teaching more geography, that you need it for understanding environmental problems. I find that when I try to teach my advanced students various things, they don't understand because they don't know where anything is.

NYSTROM: One problem, I think, in the United States is that the school curriculum is local jurisdiction. We do have strong geography programs in a few areas, but it's very spotty. In other places there is none at all. In other words, there is no national curriculum, and we have no state curriculum in most states. Consequently you have a tremendous variation. But for the most part I think it's quite true that geography is badly neglected.

KORFF: The United States is the only nation in the world where the

Federal Government does not do anything about education. It's left to the states and to the private schools and colleges.

TROMP: The degrees then have different values?

KORFF: There is a standardization procedure, an accrediting association that looks at the curriculum of a particular school or college and says, "Well, now, this one is good, and, therefore, we will accredit it," or "That one is poor, and we will not." But the rules in force are rather general, and there may be a field in which a school doesn't do well but may still be accredited because it's quite good in other fields.

DAVIS: I think our comments on education should be compatible with our comments on interdisciplinary cooperation, as we have already stated. There is almost a corollary.

JOHNSTON: Are you prepared to make a specific recommendation that the World Academy do something? Approach foundations, for example, to raise special kinds of grants to meet special kinds of needs?

TROMP: I think the World Academy could approach UNESCO on this if we come up with some concrete proposal. But I wonder also if the sections on interdisciplinary cooperation and education could be combined into one, because it is a matter of educating the people so that they will want to cooperate.

DAVIS: There are really two problems, though. One is that people who are already educated should work together. The other is to provide for the future.

The problem as I see it is that there is not very much money available to hire, let us say, environmental scientists. On the other hand, it's almost a certainty that within four years there will be quite a bit of money available to hire environmental scientists because of the way, at least in this country, the Federal programs are moving. And there will be much less money to hire high-energy physicists. There already is less. But I think the educational process ought to be in advance of the need, if at all possible, rather than merely responding to the current market. How do we communicate with the scientific community all around the world and in all its specialties? How do we communicate this urgency, this need? It doesn't do any good merely to send a copy of our report, in this country, to the National Academy of Sciences. They will file it. How do you do this?

TROMP: It has to be brought to UNESCO. They can appoint a committee of a number of people in this field, and then they will try to draw up the procedures.

DAVIS: If you wanted, for example, to give a paper to the American Physical Society proposing an interdisciplinary approach to physics, there would be no specialized section of the Physical Review that could claim it.

TROMP: If one wants to get some new international problem in the schools, how does one do it?

NYSTROM: The National Science Foundation funds many summer institutes and short courses. For example, in regard to satellite surveys, there have been in the last four summers institutes on remote sensing, and these are widely taken by all sorts of people.

JOHNSTON: More are needed from the sources of pollution, the economic enterprises.

DAVIS: Another problem is that environmental science is basically, if you like, systems analysis rather than a science, because there isn't any such thing as environmental science. You need a tremendous range of disciplines, but what you really lack is somebody to pull this together into a system. The man you need to train is probably already practicing and successful. Without pulling a name out of the air, without wishing to do him discredit in any sense, I think of somebody like Joseph Magaminsky at Princeton, who is very busy developing a global model of the atmosphere at eight levels and 10,000 data points, and so forth. If I go to him and say, "Well, now, I want you to become broadly environmental in your outlook," he'll look at me as if I were some kind of nut, you see. He's much too busy working on his 10,000 data points and making his computer work.

TROMP: Let's go on to the next section, the problems related to underdeveloped countries.

JOHNSTON: An initial comment. I think we might, first of all, avoid overgeneralizing and consider the differences that exist between developed and developing countries. The educational needs are not at all comparable. There are two different kinds of worlds. Is overspecialization necessarily as much an evil in developing countries as it is in the developed?

DAVIS: I think the point was made the first day that in many cases what the underdeveloped countries need are specialists. They don't have any. Having lived in the deep southern part of our country before and after the advent of air conditioning, I would say offhand that the most significant cultural contribution to the underdeveloped countries would be air conditioning. This permits rational thought in the middle of the day.

NYSTROM: It seems to me that one of the problems is the question of priorities in many of the underdeveloped countries. Very often there are psychological or political problems in the way of sound development. They go after a steel mill or a big university, when actually what they need to do is spend the money on some lower-level technical school rather than spending $100 million on a university. The nationalistic, flag-waving approach is one of the overriding problems in many of these countries.

JOHNSTON: One of our problems here is that we don't have anyone who represents the underdeveloped, developing areas of the world, and that seems rather serious. We might be making all kinds of assumptions about their needs, their scientific needs, that are untrue. Has there been any sponsorship of a conference of scientists exclusively from developing areas that might create a better opportunity for them to discover from each other that they have been misled by assumptions that were valid in developed areas?

NIGRELLI: I think that UNESCO is aware of these problems and knows what the needs of the individual countries are.

JOHNSTON: Who told them what the needs are?

NIGRELLI: They probably have their own teams in each of these countries.

JOHNSTON: But that I think perhaps misses my point. It's always assumed that there must be a mix of scientists from developed areas and developing areas. If they were mixed together, there might be a psychological tendency for the scientists from the developed world to persuade scientists from the developing world that their own assumptions are valid for them. So long as you have a mix, perhaps this will always be so. I raise the question in innocence.

PERRIN: I think that we should take care of the fact that the needs or conditions are not the same in all the developing or underdeveloped countries.

The Pugwash movement is organizing a conference among African scientists. It will be held in Dakar, and this is essentially a conference among African and even black African scientists. The European scientists would just help in organizing.

JOHNSTON: This is fascinating, because the assumption that scientists in the main are not affected by cultural differences tends to be untrue. If Margaret Mead were here, I'm sure she would make a very effective case to support this.

DAVIS: Isn't is a reasonable statement that the principal environmental problem in developing countries is cultural rather than technological? The level of technology is available, but I think in most cases it's a cultural problem. It is probably a cultural problem in our own country.

NIGRELLI: I go under the assumption that these countries are aware through UNESCO of what technology is available to them and that they can get the information. How can we make a statement here suggesting that they take advantage of this available technology?

DAVIS: Our particular topic area is more or less cultivating resources. It seems to me that precisely the developing countries are going to have a fantastic source of future raw materials just from the very tropical nature of their environment. In Puerto Rico, for example, if you could find something useful to do with bagasse, which is what's left of the sugar cane; or if you could find something useful to do with the hulls that are left from the coffee beans, you could create a new economy, because they have tons upon millions of tons of both of these and they don't know what to do with it. In the case of the coffee bean hulls, they are almost indestructible. They will not decay. They can be buried and dug up 20 years later in perfect condition.

PERRIN: The hull or the shell?

DAVIS: The shell of the coffee bean. It's a very, very incorruptible material.

PERRIN: It can be burned, of course.

DAVIS: No, it can't be burned, and it cannot be decayed, decomposed; it can only be dumped at sea, because there is no other way of getting rid of it. It would have to be burned in a very high-temperature furnace. You can't light it with a match. There are many, many raw materials, important resources, that, when we have learned how to use them, could be important both to resources and to economic development of these countries.

AGLION: Sometimes the costs are so high that they can't do anything with these things.

DAVIS: We did some experimenting, for example, on new methods of making pulp for paper, because neither of the usual methods produce a usable pulp. If this were an area of research, if people would investigate the use of tropical products, this might be one of the more useful things you could do for the developing countries. Could that be an objective for resources for the underdeveloped countries—research on the utilization of the products of tropical countries?

JOHNSTON: I wonder if the World Academy might make some effort on behalf of the international scientific community to reestablish communication with Chinese scientists.

DAVIS: Interestingly enough, in the environmental area, meteorology is one of the few areas of human activity to which there are few international barriers. For example, we receive weather data from every country on earth, including China. We have a hot line, if you will, to Moscow, the only one

besides the President's, and we transmit daily forecasts, satellite pictures, and everything else to Moscow, and they transmit theirs to us. We transmit weather information to Cuba every six hours over direct line to Havana. In fact, we can talk to Havana on the telephone, and nobody else in the United States can. There are mechanisms in the environmental area that already exist.

JOHNSTON: You can speak to them, but they don't speak to you, as far as China is concerned? Is it mostly one-way communication?

DAVIS: No, not at all. And that's only one field. For example, in geodesy, we have five matched telescopes around the world to take pictures of 18 stars on every third night. The function is to determine the tilt of the earth on its axis. Without these data, nobody can have a navigation chart. So, throughout two world wars, for the last 75 years, data have been exchanged continuously between Japan, Germany, the United States, and, I think, China. There are, thus, mechanisms in the environmental area that are already in existence for international communication, that are above and beyond any political and cultural differences. We have an unusual point of entry, better perhaps than any other branch of science. One of the advantages of spreading environmental learning will probably be an improvement in international communication.

JOHNSTON: It's my understanding that the Chinese scientists have made some very striking advances in a practical sense in eliminating certain insects on a very wide scale. This suggests that some importance be given to better communications with scientists in other developing areas. I don't know what the World Academy's role is in this, but the question has been raised, if anybody else would like to speak to this point.

NYSTROM: This is better operated in Washington through the academies of science that do meet regularly.

JOHNSTON: The scientists in Washington are extremely restricted. They are almost completely unable to make any meaningful contact, according to my information, with the Chinese scientists.

NYSTROM: I think a body like ICSU is a more appropriate body.

KORFF: ICSU got turned down by the Chinese.

JOHNSTON: In the second half of the 1950s, Chinese scientists were al over the world. They were flooding international conferences, I am told And now it's down to a trickle.

NYSTROM: This is Chinese policy.

DAVIS: We might recommend an attempt to broaden the base of participation in future discussions to include countries not now represented.

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REPORT OF WORKING GROUP
CULTIVATING RESOURCES

Rapporteur: Douglas M. Johnston

The Problem of Environmental Resources

The electric light bulb was invented in 1885, and in 1969 man set foot on the moon. In historical perspective, this cannot be described as merely technological progress but should be viewed as a quantum jump or almost instantaneous change. What is happening now is new in the annals of human history. We are in the midst of an experience qualitatively different from anything that has happened before to the human race. Even more disturbing, this particular experience will probably not happen again. Thus, we as a race have one and only one opportunity to make the choices that lead to survival. In our age, a production economy is needed to sustain the standard of living we have all come to expect, but production causes waste and pollution. We are rapidly depleting the earth's resources and polluting its environment.

At the same time, we cannot turn back from the technological revolution. Knowledge exists in the mind of man, and if a catastrophe were to destroy all our physical constructions and tangible evidence of technology, we could rebuild within a few generations. Further, we have come to expect a high degree of individual freedom as well as the material benefits that technology permits. The basic problem thus becomes: How can we preserve the resources of the physical environment and at the same time preserve individual man and his aspirations? Although we are still in the midst of a period of high technological change, trend-curve analysis suggests that the revolution of physical science and technology may approach an asymptote by the turn of the century. By that time, our goal should be the achievement of some kind of steady-state solution in which population, technology, and resources come into balance. Between now and the end of this century the current revolution of physical science and technology will most probably have run its course. Today, new revolutions based on the biological and social sciences are under way and must be factors in our planning for the future.

Consideration of Alternatives

The group considered two mutually inconsistent approaches to the problem of environmental quality. First, an alternative sometimes advocated today, to check further technological evolution and population growth, reduce production, and lower standards of living in the developed nations until the rate of consumption of resources and the rate of environmental pollution come within tolerable limits. Second, we can seek a nearly closed ecological cycle in which resources consumed are later recycled and even pollutants find their way back into the cycle as useful raw materials for production. Such a cycle, of course, would also depend on arriving at a stable population level.

It was the consensus of Working Group A that the second alternative not only is the most feasible from a human and technical point of view but is also the most conducive to the preservation of a maximum level of individual freedom.

Requirements to Achieve a Closed Ecological Cycle

In order to achieve a closed, or nearly closed, ecological cycle of resources by the end of the century, we must identify what is needed in the way of information, research, technology, and social and political action during the intervening years.

The Group identified the following requirements:

1. The quick availability of data in readily usable form about all aspects of the physical and biological environment.
2. Indices of environmental quality and of resource loss or gain in a form suitable for management decisions.
3. The technological means of controlling different elements of the environment as required to maintain the cycle.
4. Institutional mechanisms for conducting analyses of the environment and reaching decisions on necessary action.
5. Social, political, and other means of bringing about such necessary action.

Specific Recommendations

Environmental Quality Indices

It is clear that the problems of pollution of the total living environment cannot be divorced from the larger context of environmental quality. Even the major parameters of acceptable quality are not yet sufficiently known or clearly defined. Only after analysis of all the important factors affecting environmental quality will it be possible to establish criteria and indices of environmental quality for different regions and for different environments (outer space, atmosphere, land masses, and sea). In order to accelerate this process, the group believes that an appropriate working committee should be formed by the World Academy to undertake the following tasks:

1. To list the critical environmental factors according to their relative importance in developed and developing regions;
2. To identify areas of required research to permit the development of appropriate indices of environmental quality on a worldwide basis; and
3. To prepare a report before the Stockholm Conference in 1972.

Resource Development

It is imperative that those responsible for resource development employ greater care in reducing the dangers of waste through underuse and misuse and, in the case of renewable resources, through overuse. A long-range

goal should be the establishment of a steady-state ecology on a global basis that approximates a closed cycle.

Disposal of Waste

Among the many aspects of the waste disposal problem, the Group emphasized the immediate need for more imaginative economic policies to provide a positive incentive to industry for more easily disposable products through bonus or compensation arrangements and by penalties for those industries that produce less costly but less easily disposable products. A long-range goal must be complete recycling or reuse of waste products, with the intermediate goal of storing waste in a manner that permits its future availability, except in cases where such storage would constitute a hazard.

Antipollution Measures

In addition to the conventional research to reduce pollution hazards, more attention should be given to biological approaches: for example, the anti-water-pollution experiments of Dr. Boyko, using higher plants to destroy pathological microorganisms and toxic substances, that may result in low-cost antipollution measures, at least in smaller communities in both the developed and the developing areas of the world. A long-range goal should be a reusable cycle of all pollutants.

Satellite Surveys of Earth's Resources

In view of the many potential benefits available to the international community from satellite observations of the earth's terrestrial environment, the Group strongly recommends that in all future planning of human environmental activities, the actual and potential implications of these surveys be considered. Organized efforts should be made to ensure that the actual results of experiments will be made fully available.

Problems of Communication

Interdisciplinary Cooperation. Perhaps the most serious dangers to the future state of environmental studies will be those that arise from inadequate or ineffective communication. The interdependent character of environmental studies requires close and continuing collaboration among the scientific disciplines, with full participation on a personal and institutional basis at all levels of professional and research activity. For example, the gap between the medical profession and other scientific disciplines is an especially serious obstacle to progress in the medical sciences in most countries.

Professional Attitudes. Many scientists have a strong conviction that basic research can be considered of professional significance only if it lies within the confines of their given specialty and has as its purposes the acquisition of knowledge, without regard for ultimate application. In meeting world environmental objectives, leaders of disciplinary research must consider environmental problem solving, which will cross the boundaries of scientific specialities, as of comparable professional status to that of purely disciplinary research. Such a change in attitudes would not only advance progress towards essential environmental objectives but also help improve the public image of science and bring awareness of new tools and techniques to the individual specialties.

Education. Efforts should be made to publicize the dangers of premature specialization in the basic and applied sciences and to experiment boldly with flexible courses of instruction designed to broaden the general understanding of present and anticipated problems of environment and society. It is recognized that this may necessitate a slight reduction in the length of training in highly specialized areas, but it is believed that this sacrifice would be more than offset by the advantage of having a larger number of broadly based specialists.

Training. In designing training programs for scientists in the developing areas of the world, it is often overlooked that in addition to obvious differences in race, culture, religion, and economic level, their extreme climatic conditions affect disease patterns, working efficiency, and other aspects of behavior. Simple improvements can be made within the microclimatic environment and in the use of available resources to reduce the adverse effects of such conditions. The group recommends that the World Academy participate in the promotion of environmental studies training centers in developing areas of the world.

General Recommendations

The group requests the World Academy:

1. To bring these various considerations to the attention of the appropriate specialized agencies, such as FAO, ILO, UNESCO, WHO, and WMO.
2. To accept responsibility for maintaining liaison with these agencies and assisting in the realization of these recommendations by establishing a permanent committee as the continuation of this working group;
3. To encourage members of the World Academy to recommend implementation of the above proposals to their respective national governmental bodies; and
4. To increase its effort to bring to international conferences scientists from countries often unrepresented because of financial and political difficulties.

* * *

Working Group

POPULATION, HEALTH, AND FAMILY

Control of Population: Numbers and Quality
Environmental Control and Public Health
Genetic Engineering
Family Institutions

Cochairmen: C. H. Waddington, Carl-Göran Hedén, Rollin D. Hotchkiss, Emily Mudd, and John B. Calhoun

Participants: Jacques Bergier, Johan Bjorksten, Robert Cancro, Yusuf Ali Eraj, Arnold J. Friedhoff, Alexander Hollaender, Lawrence R. Kegan, John Norton Moore, N. Henry Moss, Stuart Mudd, Larry Ng, Ruth Sager, William Simon, Richard Wakefield, Walter N. Walmsley, James Wellesley-Wesley

WADDINGTON: I think we're going to try to talk at first very generally around our topics, and try to decide what it is we want to do. It may be we want to set up smaller groups for the particular subjects. We have been given the task of considering five topics: control of population; numbers and quality of population; environmental control of public health; genetic engineering; family institutions. It is a rather formidable list.

It's not clear yet what kind of result we are aiming for. Are we aiming at writing? I think the Conference has to put something in writing eventually, but I don't think it's sensible to think that a group, in the space of two or three days, can sit down and write any detailed examination of the population problem that hasn't been said a million times before. So anything we put in writing has to be rather carefully selected. One possible way to approach this would be to start with some consideration of general goals in these fields, and then go on to a consideration of the methods of approaching these goals.

Prof. Ruth Sager some time ago prepared a statement that might be a useful beginning, a focus. It is a statement of what she has called a biological bill of rights for man, and it is a categorization of possible biological goals that societies ought to be able to work toward.

SAGER: It's not clear to me right now the manner in which this kind of formulation could be used, but I would propose it as a starting point for discussion. It's very general, but the aim was to try to define what a newborn baby might have the right to expect in the world, in as specific biological terms as possible. The difference between this and many of the 19th-century statements about the rights of man derives in part from the fact that we know much more now than we knew a hundred years ago about a developing human being's needs and in part from the increasing necessity, I think, to define what might be called social aims in individual human terms.

I have a great fear, as do many others, of the growing depersonalization that is resulting not merely from technology and computers, but, and primarily, from the increasing squeeze on resources, on space, and on all the other things that we used to regard as part of a happy way of life. When one starts thinking in global terms, there is a fearful danger of getting away from the individual; I thought that if one could draw up a statement couched in terms of very personal individual needs, it would become something closer to our general aim of maintaining the dignity of man, and something one could check against daily life, rather than think about some ultimate goal that is relatively meaningless in terms of one's next meal or how one is going to live today or tomorrow.

So much for preamble. I'll just read off what I've written here.

A biological bill of rights for mankind:

1. The right to an adequate food supply, free from toxic additives or pollutants;
2. The right to have clothing and shelter consonant with physiological and aesthetic requirements;
3. The right to live in an equitable physical environment, aesthetically attractive and physiologically healthful;
4. The right to an upbringing that does not emotionally malform and does lay the basis for healthy psychological development;
5. The right to free education, continuing as desired throughout life; the aim of education to be the growth and development of the individual to the fullest extent of capacity and desire;
6. The right to live in an equitable psychological environment, characterized by respect for human dignity and diversity; and
7. The opportunity for creative work and self-development at all stages of life.

This is a very pious statement, but I suggest that perhaps we might find some ways of specifying some of these things so that they would have substantive meaning. I would add one small footnote: you might think this is the sort of thing everyone would be for, like motherhood, but one person with whom I discussed this last year, a very thoughtful woman for whom I have considerable respect, said she simply did not agree with this statement and that she did not feel that individuals are born entitled to all this. So I think that there might be some argument—

WADDINGTON: On what grounds would they not be entitled to it?

SAGER: On the good old grounds that you deserve only what you work for.

BJORKSTEN: I think this statement is very well taken, but I would like to add to this list, as number eight, the right to as long and healthy a life as is within the powers of science to achieve.

WADDINGTON: Isn't that really covered under the right to live in an equitable physical environment?

BJORKSTEN: No, it is not, because "a long healthy life" implies, for example, that health be directed toward such a path—and I have in mind, specifically, aging research, which is now neglected and which should be emphasized.

WADDINGTON: This is definitely a subject for debate. Many people at first would say they wanted to have as long a life as possible, but if we had infinitely long life we could have no success. Much might be said one

way or the other on this, and it is certainly debatable, but I don't think that to increase life *ad infinitum* is a good enough statement.

MOORE: Before we get into the specifics of the very interesting biological bill of rights, I'd like to say that I think this is a very useful starting point in trying to cover the goals the working groups have set for themselves and in trying to shift the scientific and technological developments over to the policy implications. Even such things as population questions really are not bad or good in themselves; there's nothing wrong with population. It's a question of the effects of population on the other goals we have. It strikes me that what Dr. Sager has done has been to give us a good point of departure in terms of criteria that Dr. Mead was talking about. We might use Dr. Sager's statement to evaluate, then, the effects of such trends as increases in population.

It seems to me that some of the tasks we ought to set for ourselves would be, first, to try to discuss these goals, second, to see if we can extrapolate what the effects on those goals would be of the various trends that we're talking about, and, finally, to hammer out some kinds of strategies and implementation on more specific, concrete policy levels of what we're going to do about them.

WADDINGTON: I think that was just the idea; these were intended to be criteria from which you could judge and approach the population problem and say: Are we overcrowded or undercrowded, growing too fast or too slowly? These are judgments of value, and these are criteria values we might use.

FRIEDHOFF: I think Dr. Sager is suggesting that a lot of issues have been left to develop in a generally spontaneous way, and they should really be brought into the political arena and be matters for decision by political and governmental processes. I think two things evolve from this approach to such problems. The first is that these aren't really a series of goals but, rather, a series of priorities; if we determine to do one of these things we've got to give up something else. If you want food without additives, then you're probably going to reduce the yield from the land, and so on.

I think it becomes a question of deciding in a political way many priorities that we want for mankind, and I don't think that any government, at this point, really has the appropriate political apparatus for translating what people want, or what must be done to preserve life on earth, through some political process into an effective mode of action. So, I think we can't consider these priorities we've projected without considering also that they will need certain changes in the way in which we govern ourselves.

WADDINGTON: I originally suggested a sequence. We should first consider, to some extent, the goals or the directions; they are, as you say, directions rather than specific goals; then we could consider the ways of working toward them. We might have to modify the directions by saying they're impractical.

CANCRO: I basically concur with this position and I have no substantive disagreement with this as a priority. What troubles me is how we can translate these priorities into operational realities.

Even in Dr. Sager's bill of rights there are certain problems—for example, in the aesthetic area. What one person considers beautiful another considers ugly. I recall, for instance, my first experience in Miami Beach, and I looked about me in horror and someone said to me, "Isn't it gorgeous!"

and I realized that we were both from the same planet. Each of us was convinced that the other was quite different.

Once you begin to get into such concepts as aesthetic requirements you have to find groups, and then these groups come into conflict with each other. And here, too, I make a plea, because this is basically a scientific group, that we get out of a certain mode of problem-solving thinking, in which we will solve the problem, bring the solution to the body politic, and say, "Here is the right way." There is no solution; we can, perhaps, generate options with specified benefits if we're able to get a handle on these very subtle issues. Then these options can be put to the body politic and we can say, "Well, for us option A is the most attractive, and in another area option C would be most attractive."

But this will work only if we don't lose sight of the total system, so that what happens in a developing nation that wants to increase its population has extranational implications with what happens if we want to cut back on population.

HOTCHKISS: I think Dr. Cancro is putting his finger on one problem, but isn't it just the very genius of choosing the word "aesthetic" that allows for the fact that what's aesthetic for A will be A's goal and what's aesthetic for B will be his? If this program said we had to have maximal engineering and high-rise buildings because we had that aesthetic, that would be wrong. But aesthetic can be a general statement, and our kind of problem will work out of our way of handling the question.

WADDINGTON: I think the sixth point in Dr. Sager's statement—respect for human dignity and diversity—possibly needs strengthening. Speaking as a geneticist, I would say that the strength of a population depends on its heterogeneity. I think nobody would want to have a world in which everybody's aesthetic tastes were identical.

HOTCHKISS: Your objection is not quite fair. In an extrapolation one does attain a maximum that we wouldn't want to carry to the ultimate limit. We should look for those things that galvanize activity under different heads.

WADDINGTON: Do you think this should be a separate item, or should it be put into number 3?

EMILY MUDD: I think number 3, since the physical environment is involved.

WADDINGTON: Physical environment, aesthetically attractive, and physiologically healthful and conducive to a long, productive life—something of that sort. You will want a separate item?

BJORKSTEN: I would like a separate item, because I don't think we have the specific steps in mind.

HEDÉN: I would like to note the extent to which these points are similar to the Declaration of Human Rights as expressed by the United Nations. These, however, are put in more biologic terms, which I think is useful. But in terms of the implication, of the impact, I think they have a much better chance of acceptance—if we can tie in with things that have already gone through the political mill, as it were.

I would also like to say that as far as the effect of any statement that we propose is concerned, there is a very interesting development now occurring, and that is the concern for the human environment not only from the individual states, but also on the international level.

As you know, the United Nations will have a special conference on the

human environment in 1972. It will be one of those enormously big things; it will take place on the governmental level, that is, ministers will meet, make decisions, and take action. The decisions will have to be made before the conference. There will be very few scientists along, although I would assume there might be a few who could give semantic advice. So it is extremely critical what we can achieve at conferences like ours during the period until 1972. We have good ways to channel this type of thinking into actual political decision making if we phrase it properly. From that point of view I'd like to emphasize trying to tie in with the human rights declaration as much as possible.

WADDINGTON: I think this statement gets a great deal of its strength from being placed on a biological basis, because the biological basis is much more incontrovertible than any sort of natural legal rights that one could argue about at length.

NG: I'm not sure what is going to be accomplished by another bill, call it biological or not. Perhaps at this point we could devote our attention to certain of the fundamental transnational problems, for example, hunger and malnutrition—both are biological—some of the problems that we can pinpoint.

At this point I would like to add a question: What is the purpose of a statement like this? Is it merely going to add to the accumulation in libraries as a very elegant, poetic statement?

WADDINGTON: Anything we do *is* going to sit in a library for some time. We are not a governmental body; we in this room cannot change the laws of any state in the world. Anything we do can be only a recommendation. We are setting forth a statement of what we see are the biological requirements. And I think the strength of this statement is that we don't concentrate only on purely physical things, such as an adequate food supply, but also state the psychological and social needs of men, which are usually forgotten in such statements.

SAGER: I feel very strongly that there is an ethical problem on which we have as much right as anyone in the world—no more right, but certainly no less right—to express ourselves. I do not believe that a bill of rights should be in inverted commas. I think its meaning is that we're stating a value judgment; we are making an ethical judgment. We know we don't have the power to feed the world; in fact, any political significance is the significance that comes from a group of people issuing such a statement saying that everyone in the world is entitled to have this kind of perspective, of what to look forward to at birth, and that we see this as a right; its political meaning is derived from that.

What primarily concerned me when I formulated the statement was whether it's realistic in the most honest, pragmatic sense. Is there, in fact, enough food in the world, and is there any hope that there could be, by any reasonable reorganization? Is it technically possible of fulfillment, in other words, or is it dishonest, in the sense that it's impossible? If we were able to substantiate or somehow include references that would substantiate the possibility, that would bring the statement into a much more realistic frame. I'm quite concerned about this point, because it is a real problem.

I did speak with some people in the U.S. Department of Agriculture whose opinions I value highly, and I suppose there is no single, authoritative, definitive answer to this question, but at least there are people who say that the problem is not a technical one: essentially it's a problem of poverty. In other words, it's a problem of social organization that there is not enough food in the world. It's not a problem of the impossibility of the technology.

HOTCHKISS: What is it, then? What *did* they say?

SAGER: That it was poverty and politics.

HEDÉN: I have understood that what we come up with will be a document that is, in a sense, an interim document, because it will then be submitted to other people by a continuation panel of each working group. That is, we are supposed to create a continuation panel to carry along our discussions, to communicate with others, outside of this room, to get their points of view. So what we do here is no final answer.

Now, about the food situation: at another conference recently, a leading American participant stated that there were three predictions with regard to the time the "great famine" is to be expected: 1984, 1980, and, at last, 1975. I think it's quite irrelevant when it occurs. The essential thing is the time before such a situation occurs: the time for action is short.

WAKEFIELD: Last year I heard an authority in this field express his alarm about the concern over malnutrition and starvation. He says it's getting too much attention and that technologically we have the means to feed 90 billion persons. The burden of his talk was that our concern with that issue was obscuring other issues that may lead to our doom in other ways.

WADDINGTON: We have to be very careful about estimates exclusively from nutritionists. They usually forget that you get these high yields from agriculture with vast inputs of fertilizers, and where you get the power and the fertilizer plants built is not so clear. One might say we have the technological knowledge to feed 35 billion, but the practical possibility of producing the fertilizer and putting it on the ground, where it is needed, is not the same thing at all.

HEDÉN: When one discusses this point one should, perhaps, place the emphasis on the children, the nutrition of the very young child. It is clear, now, that malnutrition at a very early stage in life produces irreversible effects. If you consider the children of the world—limit your consideration to that—there is no technological excuse for not taking care of them. With the older population there might be overriding economic considerations.

ERAJ: We are not getting down to specific things. Should we start discussing something really specific?

WADDINGTON: I don't think at this stage we should. We are still exploring the situation. I think if we start right in on numbers—

ERAJ: No, I don't mean that.

STUART MUDD: I think in a group discussion the first question is to have something to discuss, and I think one of the problems with our Government—or any democratic government—is that there is so little communication between people of scientific competence and political idealism and the large number of politicians who make the decisions. I think if we can emerge with a statement that's rather definite, that has the sanction of a competent scientific group, it would be very useful.

HEDÉN: The question of political instrumentation is not really our concern but that of another group.

BERGIER: Concerning the biological bill of rights—some time ago in France, we had some very definite and very precise delineations of experi-

ments on the mind made by Germans during the Second World War; the French Government now defines these as biological crimes against the human species.

WADDINGTON: The United Nations has a panel working on dangers of technology to individual rights and freedoms; this certainly includes a lot of things concerning biological experimentation, both the extraordinary and drastic kind of Nazi concentration camps and the standard kind in hospitals testing pharmacological activities of drugs. But I think we're really concerned, here, with much broader issues—the right to live in an equitable environment, and so on.

CALHOUN: I would like to speak about the scope of our concern, perhaps an undue emphasis on biological matters, and perhaps we need to place some emphasis on the future and on evolution per se. Perhaps we should say that statements from this group should have sufficiently broad orientation to give very wide perspective as to where we're going and how our actions may affect where we may go.

WADDINGTON: I would like to try to clarify one issue. In this first right, the right to adequate food supply, where there is some doubt whether it's practical to provide that food supply at the time when it's available, Hedén noted that this is much more important in the early stages of child development, when lack of adequate food has irreversible brain damage, whereas later in life its effects are bad but not so drastic. Should we modify this first statement to emphasize that it is particularly in the first year of life that adequate food is important?

ERAJ: It is very true that not only in the first year of life, but also in prenatal life, it is very important; so much so that the health of the baby is really dependent on the economic status of the father and the mother. Then, also, after the first year the problems do not stop. Bear in mind that if you take away all food from a person, he will die in 10 days. But if you take away half the food, he will die in about three years. At no stage of life is food less important or more important.

WADDINGTON: There's no stage of life at which it is not of importance, but I still argue that at the early stage it's still more important; if there is irreversible brain damage, and it *is* irreversible, it's impossible to get back, even if the food supply improves later.

ERAJ: You are quite right in that. But, if you do take away the proper nutrition from a man who is at the university, his development—even though his faculties have been developed by proper nutrition until that time—his faculties will in no way be less damaged.

EMILY MUDD: Wasn't there a question whether the group still wanted to work with this as a general framework or whether they didn't?

WADDINGTON: I've been trying to interpret what people want; perhaps the time has come, now, to put this into the background and discuss the specific problems, such as numbers of population, and so on, and then come back to this and see if we have any new insight as to where we want to go.

MOORE: It seems to me that, although I would have a quarrel with one or two of Dr. Sager's suggestions, and I'm sure others would, we really ought to go on to the question of why we have a problem with the population increase, or with genetic engineering, in the light of our goals.

ERAJ: This is also the problem in my country: do we have the problem of overpopulation? And also, is there enough food? We come down to considering if there is enough food in the world today. I fully know the limitations of our group, but we should be able to give a definite answer whether food is available or not.

STUART MUDD: Nobody wants to tell any country it's overpopulated or that it hasn't food enough.

ERAJ: But we are trying to generate some sort of pressures so that we can make a statement. There is definitely a certain kind of program that would meet the health needs of man.

We also have a consensus that it's only reasonable that we develop programs to help limit the population. You must have some control over the number of your people. I am saying only that we should face the notion of control and see if we can justify it, and if we *can* justify it, how can we control the number of the population? If we agree on this, then we can arrive eventually at some point of departure. We used to think that family planning would control population. Can anybody really stand up and say that it will control the population effectively? In all the readings and all the papers, we are told that the population can be controlled by family planning. Once you begin with family planning your troubles are just starting and will never be over.

CANCRO: We could very quickly fall into error by talking of planetary capacity of population in terms of protein production, calorie production, and how big a population we can feed, how big a population we can keep alive. The work of people like John Calhoun, here, parallels other work that certainly suggests that there are qualities-of-life issues that go beyond protein intake and beyond calories. For example, if we produce enough calories to support a given population density and that population density causes an increase in interpersonal violence, we will have a kind of population constraint and control without even being aware of it. I feel very deeply that, when we talk about the size of the population, it's very important that we not think just in energy terms and calorie terms, but that we bring in some of these more difficult points.

ERAJ: This is exactly what I've been trying to bring out. You cannot point to one country where there has not been some improvement. If you go to India, if you go to Kenya, if you go to China and ask a man, "Are you having better food than your father?" he is sure to say yes, which doesn't mean that the level of nutrition is where it ought to be. And if you ask him, "Are you getting a better education, better clothing, a better home?" he will answer yes. That is not saying that the condition under which he lives is to be recommended. People in any country and in every country are not going to have the same difficulties that their fathers had.

CANCRO: Except that your list didn't have one human consideration. "Do you have better food than your father, better clothes?" I would ask them, "Are you happier than your father? Do you find more meaning in your life than your father?" I would ask these questions. I quite agree that I would place it in a priority. Obviously, you have to have a full stomach before you have a full soul, so to speak.

ERAJ: What I mean to say is: the happiness of life is something you cannot weigh—home, clothes, jobs.

WADDINGTON: It's clear that we are not in a position to state what numbers of population all the countries of the world should have. This would be nonsense. It's senseless to talk about anything in isolation; we must

talk about a whole complex of things in a total situation. This is the way we have to think of population, in terms of its interrelation with all of the other factors and the carrying capacity of the land.

I'd like to add one thing that hasn't been brought out and that I think should be stated explicitly: population and difficulties arising from population arise not only from sheer numbers at a given time but from rates of change. Brazil is an example. It's probably true that there aren't nearly enough people in the Amazon Basin. but it would probably be catastrophic to put large numbers of people in there in too much of a hurry; there wouldn't be the time required to develop the area to support them properly. I see the rate of approach to an optimum as important.

CANCRO: This is true in cultural and psychological terms as well.

WADDINGTON: Yes, in cultural and psychological terms as well. Housing, shelter, is one of the major problems of population, and almost as important as the whole problem itself.

NG: Keeping in mind that all bills of rights for mankind are aimed primarily at the optimum quality of life, I think the one particular contribution a group such as this can make is in beginning to dissect out the various parameters that affect the genetic and time perspectives as a part of the genetic development of man as a species.

So what are the parameters that determine an individual man's development? What are the bases that really affect the development of his behavior in longitudinal perspectives? Certainly, the prenatal period and the first few years of life are very important; the impressions and the richness of his experiences and their effects on brain maturation are important; and, as time goes on, what are the cultural and sociological and social variables that exist within his environment to impinge on him and his biological organism? What is it that will elicit from him destructive behavior rather than constructive?

WADDINGTON: How far do you think one is capable, at this time, of answering these questions? I suggest that what you are laying down is a series of research projects.

NG: I do think we have the beginning of an approach of this kind: What are the prenatal factors that affect the shaping of a human organism? What are the immediate postnatal factors, and what are those that occur after several years of life? We could lay the groundwork for continuing commissions that would lead to the groups that might be set up. One thing might be a longitudinal study of the development of a child from birth to adolescence, the biological factors that impinge on him and the sociological factors he has to deal with.

In population problems we all can take up numbers, but we do not know what inputs elicit the kinds of behavior we are worried about. Perhaps one unique contribution we could make would be to begin to delineate what are some of the more basic factors, and perhaps this might lead to the implementation, as time goes on, of such a bill of rights.

ERAJ: We come back to guidelines. This is a tentative proposal given to us. We can begin with the possibility that it is undesirable to increase the population, that the quality of life is otherwise affected. and human rights also. Can we start from this and come to some conclusion? Are we firmly of the opinion that this, at least, is what we feel?

SAGER: Yes. I firmly believe there is no room for one additional person.

WADDINGTON: In global terms you might be right, but there is an extremely unequal geographical distribution population. I am quite willing to say that I don't think there's room for another person in England. I think there is room for many more in the United States. There is plenty of room in the Middle West, and Russia has plenty of room in Siberia.

SAGER: There are specific and practical and realistic things in the kind of research now being done. I don't know the extent of competence or the desire of this group to outline research projects. But certainly, the network of interaction that results from further progress in America, let's say, becomes more practical as it becomes more evident that each increment in one area has profound effects on every other area. We are just beginning to appreciate this and to find out what is happening.

The one thing we do know is the power of the exponential rise of everything. Perhaps somewhere in the conclusions from this group there should be a real expansion in the meaning of the rate of rise. I think it's not our place to outline specific research proposals, but it might not be a bad idea to make some kind of listing of the areas that we see as important new areas of concern and research, particularly in the interacting disciplines related to these subjects.

Dr. Hedén has probably done the most thinking along the lines of microbiology and its worldwide implications, but there are other areas that other people have been thinking about. Perhaps it would be useful to bring some of that together.

HEDÉN: Microbiology can afford the opportunity to make some of these extrapolations, but there are a number of other areas where it is much more difficult to carry over. Harrison Brown, an expert on resource distribution, spoke at the Stockholm conference about the future of resource utilization. He finished up his talk with three scenarios; as far as he was concerned there were only those three. The first is that somebody hurls the nuclear bolt within the next decade. Then another civilization might develop.

The second scenario is that this catastrophe is delayed for another decade or so. In that case it's very unlikely that there would be another civilization, because we will have, by then, reached a high level of sophistication in extracting rare materials. and the kids in our schools will not know enough about growing potatoes to start a new civilization. We get beyond the point where we can hope for a return.

And the third scenario—the least likely one—is that we behave rationally. I think our only chance is to operate on the basis that we can achieve the third scenario, that is, thinking in terms of what we can do now that will have an effect on the next decade or two.

WADDINGTON: Of course, his scenario was not based on considerations of population; it was based on the exploitation of easily exploited resources, and his major point was that if we had extracted all the easily minable copper, or similar materials, and then the whole civilization was wiped out by an atomic war, it would be very, very difficult to start again. This is a problem parallel to that of population, but it's not actually the population problem. It is a great increase in population utilizing this vast amount of material resources per capita, as Western countries do.

CALHOUN: I have three scenarios at least mentioned in my paper, directed both to evolution and to population. The analysis that is briefly given in the paper and the conclusion is that the optimum world adult population can be predicted as somewhere in the neighborhood of three and a half billion. What

that population is when that three and a half billion is reached will determine which scenario materializes or which we choose to have materialize. If the historical pattern, which is unfortunately based partially on the equation of shortening the interval between doubling times, continues more or less at the rate it is at now, we would have roughly about nine billion people at the time we have three and a half billion adults.

If we take the ecological model—which is, I think, a very subversive model—and have a stable population, we must start making decisions based on predictions that we would have something in the order of 7.5 billion people. The reason for saying this is subversive as a doctrine is that then we enter a period of complete stability, which has never characterized man, and that would lead essentially to global traditionalism, in which every role being played would be replaced by someone playing a similar role.

In the third scenario we choose to go into a negative population growth that will persist from now on, and this would require—in order to initiate this by the time we have three and a half billion adults—sufficient reduction in births to bring about a total population of about 6.3 billion.

I tried to list in my paper the priorities for consideration; the first priority is consideration of evolutionary designs, whereby we take a total systems approach to find out where we're going. The second is the development of supportive means for more rapid value change with conflict resolution. The third is education and opportunity for fulfillment of potentiality, this being the major thesis. The general theory is that, over time, this is what made man different from animals—that as population has increased, and as he's been linked sociopolitically with the aid of prostheses for information storage and transfer, there has been an increase in human potentiality roughly proportional to the square root of the population. These processes have been parallel, and we now have a chance to choose as a central goal the continuing increase in human potentiality. We really have to decide that one of the priorities is with respect to this.

The fourth area is the enhancement of the linkage of individuals and institutions into communication networks. This is the developing of the function of brain—an evolutionary process.

And fifth is family planning. I put it far down on the list, because I think these other items are requisite to make family planning effective.

The final item is, in the long run, the most important: the promotion of creativity, because the most precious commodity in human evolution has been the creative individual. It's always been the positive feedback—the devious more than the negative—bringing stability; otherwise man couldn't have changed or adapted over time. This is actually the first priority, but temporarily some of the others override it.

WADDINGTON: I think most of us probably feel we are talking about a temporary situation, and you have proposed, essentially, increasing the potentiality of man. Dr. Sager has proposed: "Let's bring all mankind up to a reasonably satisfactory level. If we can get them up there then we can start talking about improving and going beyond the best we've got now."

CALHOUN: I don't think we have time for that.

WADDINGTON: If we can't bring mankind up to the best level now, we haven't much chance of going beyond it. If we are talking in terms of a very critical situation, we've got to restrict our sights to some extent, rather than speculating about a superpopulation linked together by communications networks. We're confronted with much more immediate situations right now.

We come back to the statement that it is undesirable to increase the population of the planet at such a rate that the quality of life is either further depressed or prevented from rising. I think we'd all agree that it's not very meaningful to talk of the population of the planet in purely global terms. There are different situations in different parts of the globe. But we could state that it is not desirable for any part of the planet to increase its population at such a rate that its standard of living or its quality of life becomes depressed. This would mean that different parts of the planet would decide for themselves what is best for them.

ERAJ: Do you think this is a global problem or a national problem? Could we recommend that every nation have a population commission of its own? I am quite certain that if each nation sat down and thought, it would find some solutions. There has been no movement, however, to force governments to have such commissions on a national basis. I don't think we're going beyond our powers in making this kind of recommendation. If every government had an objective population commission it would be very useful. Then we come to the means at hand. We know we are not using them effectively at present. This is where family planning came in, in the first place. In my country—Kenya—if anybody has more than four children we don't give any tax remission. But in the United States or in England you can have 19 children and still keep on having them. In another country, if you have more than three children, you are taxed additionally.

This is a relatively practical and realistic technique. Many nations have population limitation as a central goal, but I contend that every nation should not consider only the family planning method of controlling population, which we know won't work, because it is not working even in the United States, in spite of widespread use. The population will increase by 50 million from 1964 to 1980. During that time in the whole of East Africa we will have increased only by 10 million. So, we should make a broad recommendation for every nation to set up a commission to find out what methods would allow that nation to realize its goals. I suggest that this would work and would offend nobody.

WADDINGTON: I think this is a good idea; but a number of countries certainly have population commissions already. It is necessary to make the techniques of contraception known and available and to have some propaganda in favor of their use. Without that, other modes, like taxation and so on, couldn't be operative. Merely to levy taxes would not work unless there were acceptable contraceptive methods available to the population. I think we should emphasize the importance of national population commissions, the fact that they should consider all methods of control, over and above the purely contraceptive-technique methods. But that's only the beginning of what we've got to do.

CANCRO: I want to remind Dr. Eraj of something said earlier here about the unreliability of projections and comment on the two figures he gave for East Africa and the United States. Both figures are projections based on past performance. I read recently that the population rate in the United States has dropped very sharply in this past year and has almost leveled off. So some projections can be quite misleading.

Basically, I strongly agree with your suggestion about national commissions, but I think they have to have some extranational, transnational inputs to their deliberations, because a particular government at a particular time in its history may set certain goals it believes to be necessary, on a short-term basis.

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Basically, I strongly agree with your suggestion about national commissions, but I think they have to have some extranational, transnational inputs to their deliberations, because a particular government at a particular time in its history may set certain goals it believes to be necessary, on a short-term basis.

I recall that under Hitler there was an emphasis on raising the population shortly prior to the onset of World War II. I think one not only has to consider the national aspirations but must try to bring other inputs to those deliberations: the quality of human life is the goal the commission should try to optimize, rather than merely say, "Well, we will suffer for one generation and then we'll be so many that we'll be able to do X, Y, and Z, and then we'll really have a better life." People often do think in that way.

ERAJ: I will warn you that any extranational influences will ruin the whole issue. With the mistrust of nations for one another, if anybody came along—like the United States—and said, "You must cut down your population," it would look very presumptuous.

CANCRO: I'm not saying this additional input would have to be from the West.

ERAJ: Let each nation produce its national commission and you will be surprised how objective they will be. If they sit down to work on it, I assure you they will produce something usable.

STUART MUDD: Can't we enunciate certain general principles and leave the detailed application to national commissions? We can't legislate here on details. You might say stereoscopy is a considerable element of beauty in the Kalahari Desert but it wouldn't be in New York; we can't legislate about things like this.

WADDINGTON: I think you're throwing away the baby with the bath water. There are considerations that, from the point of view of humanity in general, need to be supplemented to the national bodies.

It is true that if one nation comes to another and says, "You must cut down your numbers," it is obviously going to create great resentment. We are not representing any one nation; we are not ourselves nationalists. I think we conceive of ourselves as representing the world body of science rather than any national point of view; therefore, these criteria, which arise from general biological considerations, seem to be legitimate to bring to the attention of national bodies. There have been national bodies that have been objective in their own terms but not in world terms. I think there are humanity objective points, which are quite legitimate to put forward, without being intrusive about it.

HOTCHKISS: I'm beginning to consider this problem more in terms of the adjective. There is aesthetics and then there is aesthetics, and aesthetic is an ideal, something about which you cannot compromise. I feel that most of the adjectives in this statement are "adequate" and "appropriate" and "desirable" and "equitable"—even one of the nouns—"human dignity." When we say there are populations and there are populations, we all agree, and world population is one thing; we can add it up. But we can't make rules about world population and try to talk about it abstractly. There are food supplies, types of shelter, and so on. So I suggest a statement that is good enough as a working bill of rights, and if we wanted to modify some of the adjectives we could, but we would not back down on our adjectives in implementing the statement.

Another thought: The way the outgrowing population advances is not a problem merely of food supply. We have in this country, too, a problem of distribution. But the pressure that is felt, everywhere—and we can certainly testify to it in the United States—is that as a population grows we feel increased anxiety and tension and hysteria. These are rather intangible things, but they are actually the way in which man's dignity and happiness are threatened as population gets out of hand.

It seems to me that when Dr. Sager said the world cannot support one additional birth she was thinking of this problem of anxiety. It is true she was thinking of a long-range anxiety, felt throughout the world, not her own feeling. We must bear in mind another psychological factor, too. In the United States, for instance, there are many people who would feel abused if more than three —a couple and one child—slept in one room. But there are places in the world where one room must hold four or five or six people. The thing that really oppresses is the feeling that we do not have adequate room for growth. I would, therefore, submit that just as real as the food supply are the psychological factors that come to bear as population growth outruns the capacity for the social possibilities of that population.

WADDINGTON: I do agree that anxiety is one of the things that give people this feeling of being oppressed by too many neighbors around them. This differs greatly in urban populations and rural populations. One major factor in the present population increase is the enormous rate of urbanization, which grows about three times as fast as the population with the changes in agricultural technology. You can't consider population numbers without considering population distribution. But we have to try to break these complex things down into facets that we can speak about more or less separately.

HOTCHKISS: Let me strengthen my point a little. We know that man is capable of living in a state of high population density, but we realize that we are not dealing with a biological reality here, as far as population is concerned. On the other hand, we are very much involved with a question of dignity, and this is an important point. There is a sense of the future; the sense of whether the limitations are increasing or whether the limitations are decreasing.

CANCRO: I agree. We can think in terms of a range of options, in the sense that there are some people who seem to function best in high-density areas; others seem to function best in low-density areas, but circumstances do not allow them freedom to live in the country or live in the city, or to live in some intermediate-density area. Not only is there a range in terms of the population density individuals function best in, but there are changes with individuals at different stages of life. A boy at 18 may love Manhattan and at 35 may want to live outside of it, so that in looking at a population from the point of view of psychological adaptation, one has to ask questions like, "How many possibilities, how many options does this society offer people?" A range of density, for instance. And if that range is terribly narrow and one must adjust to a given reality, then the likelihood that people will get into difficulty increases.

WALMSLEY: My sense of what is taking place here is cause for anxiety, and it's not quite the same anxiety expressed by others about this planet's supporting one more human being. My anxiety is over the fact that we seem to be defending the Western industrialized world. We seem to be defending conspicuous consumption, and we are prescribing, and this is somehow to the subversion of sensibilities of underdeveloped countries for which *we* have solutions in terms of population control. I don't mean to say that I don't believe in family planning, but I would be very cautious in pressing population control. I mention this as a warning because it's a sensitive area. I get the feeling that this parochial approach to maintaining our own standards at a cost to the underdeveloped world is dangerous.

EMILY MUDD: I go back to my earlier remark—that Dr. Sager's statement may have been a very excellent one—but I didn't have any feeling that the group really responded to it positively, or negatively: that it was just there, and we began dealing with it with words and adjectives. I would like to know if we really have a basic interest.

I think there have been a lot of beginnings and involvements; people have been talking about population and family planning, interspersing it all through this conference. They are two different things. I certainly would go along with the idea that it's one thing to discuss family planning and what one can do, and another to assume that *we* have the answers in the Western cultures to population control. So maybe we should talk a little about what family planning really is. To me family planning has many, many implications, and I would like to go at them from the psychological angle. One, we have certain medical methods, but we have no ideal methods. I work in the Medical School of the University of Pennsylvania, and I am now doing a special study in the Department of Obstetrics and Gynecology in connection with prenatal clinics. In these prenatal clinics we deal with the fact that 95 percent in our clinic, are from the city's black population, so we have garnered a good deal of experience with different points of view. We have a large private clinic, also, where the staff deliver patients of a more affluent background.

But my feeling is that there are many structural and psychological problems in the implementation of family planning. In a big hospital you have one kind of problem of communication between departments. In a rural community, in Mississippi, with a black population that has a physician who goes from village to village, you have another kind of problem.

There is the whole question of education in advance: are you trying to do something *to* people or are you trying to do something *with* people; the relationship between the nurse and the patient and between the doctor and the patient; and the feeling of the woman toward the future, particularly—and I think where one can always work with women is—in their feeling about their children, what they want for their children.

Unless we can in some way relate ourselves to the way fathers and mothers feel about their children, the whole question of family planning or a national view about population is meaningless; you really have to go to them. I know we have people in this group who have had firsthand experience with these various approaches, with both the psychological and the structural, and the academic and the practical problems in this area; I would like to throw this out for discussion.

WALMSLEY: I would just express an anxiety about a parochial point of view, both as to country and as to discipline. Also, the stress seems to be on women's attitudes, and there is no reference whatever to the man's attitudes, and what he can do to be of assistance and usefulness in this problem.

ERAJ: I have been associated with family planning for many years and I have found that its use differs with different people. Very few people know what it means medically to us in Africa. Family planning to us means that if a woman has a child she comes to us and says, "Well, Doctor, when do you think I could have another child? I want to have another child after four years." Then, the Government and the health profession are both obliged to help her. Then another woman comes to us and says, "I've been married four years and I haven't got a child." Many factors can be jeopardized by not having a child.

So, in our country our application of family planning is twofold: to help those who want to have a child and those who do not. We have proof that in the developing countries more women between the ages of 15 and 44 die of unplanned pregnancies than of any disease known to mankind. We also know that family planning does not effectively control population anywhere in the world. So, perhaps we can think of family planning as oriented to conception control, as well as helping women to become pregnant.

The limitations of family planning have been very different in different countries. In the developing countries the main difficulty has been the personnel—the doctors. The average woman is not like a cow; we can't expect that she will come there and any qualified doctor or midwife will put in an intrauterine device: this has never satisfied women, even those from the lowest stratum of society.

We have not had enough clinical facilities. Many women who come to us are already suffering from some ailment. They have malnutrition; they have anemia; they have pelvic infections, and unless there is a doctor who can diagnose such patients, and no matter what advice he gives her—the pill or an intrauterine device—she thinks that because of this particular thing she's been feeling sick and she tells the others and they become discouraged. We have had many people come to help us, which we appreciate. We have had considerable help from many different countries, but, somehow or other, their orientation has always been on population control, and then they have sometimes been disappointed.

We must be realistic enough to understand the differences. We definitely feel that all the methods now available for conception control leave a lot to be desired. And we feel, also, that not enough research has been done. Much more research has been done on cancer, which does not afflict as many human beings as do unplanned pregnancies.

A small fraction of that money spent on research for better methods of family planning would be most useful. For instance, I visualize that a woman could tell, by using a small piece of paper, at just what part of the month she is. This is not just fiction; we already can determine certain urine changes and changes in plasma. By tomorrow we may be able to devise a method by which a woman can tell exactly where she is in her cycle, and then she could just abstain for a little while; then the problem that now faces us could be solved.

I am going to recommend that more money be spent on research in family planning to develop more useful methods.

FRIEDHOFF: I think the issue of population control itself is really predicated on a number of prior considerations that aren't very clear. For instance, population control in the United States is concerned primarily with the fact that we live in too-crowded cities. It isn't a question, really, of food supply, although population control in some other country might well be predicated on the food supply.

One of the problems in getting general agreement on goals about population control is that there isn't any unitary goal that we can establish that applies to all parts of the world. I think this gets back to what I said before in regard to Dr. Sager's bill of rights, that the crucial issue that precedes even the questions we're discussing now, which are very critical for the world, is that there hasn't been any process—any political process—in which these factors have been considered and have been given high priority in world government; even though we're sitting here and discussing it, we are still not coming to any modes by

which these decisions can be made, in a way that they would reflect the priorities that have been given them in a given locality or even in a given country.

WADDINGTON: You say there is no political process by which these things can be discussed. But could there be a political process until we have discussed them and brought them to the attention of whatever body there might be? Aren't you saying, in effect, that these are very difficult questions; let someone else decide them?

FRIEDHOFF: Not really, because I think the act of establishing a mechanism for the consideration of these problems would in itself be a great step forward.

WADDINGTON: But I'm saying you have to know what the problems are before you can—

FRIEDHOFF: Problems affecting the environment; the quality of life; the sanctity of the biological individual—whatever we might call it. These problems should be elevated to the same level as problems of recognition of Red China. It reminds me of the old joke: my wife lets me make all the big decisions and she makes all the little decisions. She lets me decide about recognizing Red China and she decides whether we should buy a house.

I think this is the same sort of thing. We have political democracy in many countries to decide these big issues, but the other issues, which are really more vital and closer to our hearts, are not involved in that same political process. To me it seems that one of the crucial things that we ought to consider is some strong assertion that these should be elevated to a high status in our political life and in the life of our country—of our world.

EMILY MUDD: I wonder whether we couldn't think of the question of family planning in terms of fundamental rights. Has anyone a right to tell a woman she must have a baby if she doesn't want to? Does a female of the species have a right to decide for herself whether or not she wants a baby? This is a very fundamental human right in terms of quality, in terms of dignity.

CANCRO: Let me respond to that as a psychiatrist rather than as a male. I basically agree with you, although I can't accept your formulation. Yes, she does have the right, but so does her husband.

EMILY MUDD: Absolutely!

CANCRO: Not to sound like a male liberation movement, men have rights in these matters, too. As long as the family remains a social unit, then it is a decision that both must be involved in, just as the right to abortion is a right on which the father of the child should have some decision-making input. It is not solely the woman's decision because it's her uterus. The people who are immediately and directly involved must have a voice in this decision-making process. Family planning is a right independent of its effectiveness as a birth control technique, and people have the right to the information and the means for the systems that will make this a reality. I think this is something that has to be recognized as a right in its own regard, even at the expense of the birth control or the population control side of it.

BJORKSTEN: We hear a lot of discussion about developing countries. Just what do we mean by that? I would hate very much to think of the United States as a country that is not developing. We particularly come to this question of reproductive science, and the United States, if I recollect correctly, used to be the 12th country in infant mortality; now we have higher infant mortality than almost all the European countries.

Why is that? Having had five children in the United States and being a biochemist, I find certain differences that I think are unfortunate and may well

come under consideration. The first thing is—when we come to think of freedoms—do we think the woman should have the freedom to decide when she is ready to have a baby, or should the process be accelerated for the convenience of the delivering physician? I think a lot of the infant deaths may well be due to undue acceleration.

The next thing is the question of nursing, of human milk. In Scandinavia, for instance, human milk is something that's treated like an extremely expensive commodity, and any woman, regardless of social or economic status, who has excess milk has it extracted and it is furnished to those who do not have enough—for money if they can pay, otherwise free. It is not wasted.

Then there is the question of contact between the baby and the mother. In the United States, generally speaking, it takes quite some doing to have the baby given to the mother the first day, so that she has an opportunity for immediate contact; a considerable number of psychologists will confirm that this contact has a great psychological impact on the immediate orientation.

There are several factors in which the United States certainly has room for development ahead, and the talk about "this is a developing country; this is not a developing country," and how these lines can be drawn, is something that might well be defined. If we look at the freedom of the woman to have human milk, the freedom to have her baby when she wants, and so forth, those are not covered by any of Dr. Sager's seven points. They *would* be covered if there were a broad clause stating the right to have a long healthy life for newly born children as well as for others.

CALHOUN: Just a short comment: a study recently completed—a detailed study of births in the state of Indiana—shows, as might be expected, a high correlation between prenatal and neonatal deaths and premature births.

Furthermore, these mortality factors are closely correlated with population density, not economic status. There are issues beyond this. It's the total system and the context in which people live that must be considered, but not, apparently, in the simplistic statements on our list. If we are not going to indicate, in some way, that we have such complex relationships, we are going to miss the boat. And exactly how we get these complex considerations into the political process is extremely important. Otherwise I think we accomplish nothing by making a list of neo-18th-century statements about where we should start.

WADDINGTON: To supplement that, I think one would be quite wrong to consider a relationship between mother and child purely in terms of the rights of the mother, or even of the mother and the father. Reproduction is a biological act; it is also a social act, and certainly the child has as much right as the mother and the father, and so does society as a whole. Putting it in the crudest terms, this is another mouth to feed. In most past societies, as I understand it, what some people term the right of the mother to determine whether and when she should have a child was actually strongly limited by religious bodies. A woman didn't have the right to have a child until she was married. Practically all over the world, religion, until recently, obtained at least part of its power by what was formulated as control over the sex act: people were not allowed to have sexual intercourse unless they were married and had been blessed by the church.

But this was also, and much more validly, regarded as an approval of the act of reproduction. This is a highly speculative notion I'm turning out; today, in great parts of the Western world, the churches have largely lost their control—the control they used to exert over purely sexual behavior. I'm sur-

prised that there hasn't been more of a move to transfer the idea that something must be sanctified by a religious organization, to transfer it to the reproduction rather than the mere act of sexual intercourse. It seems to me there is a mistake, here, and a mistake throughout most of history: what you could call social approval (some people like to call it sanctification of an act that is basically a social act) has been attached to sexual intercourse rather than reproduction; and reproduction is inescapably a social act with consequences for society. I think that the act of having a baby is something that society could never leave solely to the individual. This is a contribution to society, and in the decision-making process—shall this child be born?—society as a whole must be a contributing factor. This has been done in the past, although usually through some sort of religious organization.

NG: There is a curious inversion in the sociopolitical system in most cultures, and it is relevant to birth and population control. When we suggest that perhaps the government should legislate that families should have a maximum of two children, we should realize that we've had wife control and husband control for quite a while. The government legislates how many wives we should have and how many husbands we should have, so we come down to the fact that this is really a process of direct control. I don't see that one is more sacred than the other. The decision-making process will have to incorporate this very soon if enough mothers stand up and say, "We demand our rights as a family unit," or else men and women will demand the right to have more than one husband or one wife.

EMILY MUDD: This is an interesting point, and it goes back, I think, to the fact that this country is sophisticated in some spots and highly unorganized and underdeveloped in others. Having spent a little time as consultant to a family-planning project in Mississippi, I can tell you that there are women there who are so undernourished—in Mississippi the government rulings on food stamps are such that they can't get food stamps without paying for them, and the amount of money they have to pay for them is impossible for them to get. So you have starvation of the pregnant woman in a very real sense, and difficulties of birth, and no medical recourse whatsoever. Many of the women that we treated in a mobile clinic have never had any medical service in their lives. Then, in the Northern and crowded cities, we get the divergence of views from many different cultures, where the very attitude of the culture has been carried on through generations.

So, unless a particular physician has some understanding of the point of view of the particular father and mother, when we talk about family planning, we can get nowhere. And in one part of Mississippi, there's a town that has been entirely black for several generations. They have a black mayor and black-run stores, and Tufts Medical Center has set up a service there. In parts of Mississippi, the white-controlled government is very much against the rights of the blacks, and doesn't want them educated, and doesn't want them to vote because they'll vote out those white people. The black women coming to the health center, which is run by the white establishment group, are given birth control pills; and what do they do with those pills?

They have told me what they do with them. They take them home and throw them in the garbage, even though they don't want any more children, but they feel that they're being forced. But if you work through the younger black physicians and the neighborhood women and sit down and discuss what these women want for their children, what they want for the future, if they have

enough money, what kind of family do they want, and then say, "If you wish, and only if you wish, you may have this method, or this method, or this method," and it may be the pill or even the good, old-fashioned diaphragm—which, after all, worked for many of us. And you explain that these children may have a better chance for food, for education, for jobs. The next clinic evening, she is there, saying, "I didn't realize this was something that would help not only me but my children." I think there are many ways, rather than trying to force people. It doesn't take so long, and it depends so much on the relationship of the doctor and the nurse, and the nurse and her contacts.

In each community that you're working with, and each country, you have to take the whole cultural concept into consideration. It isn't a simple thing. Unless we get at something very subtle, with more understanding of the different requirements—of the variations of human needs and human dignity and aspirations, then I don't think that we will accomplish very much.

ERAJ: We have now accepted that unplanned pregnancy affects the social, physical, and mental well-being, not only of the woman, but of the husband as well. Can we define it as a social disease, just as we define alcoholism? Alcoholism affects the social, physical, and mental well-being of a man, and we call it, today, a social disease. If, in that context, we remember that the unplanned pregnancy does affect the well-being of the man, we have no right to deny anybody who comes along and asks for treatment, whether preventive or curative. We should recommend to the medical profession that they accept unplanned pregnancy, leaving aside religious aspects of the problem, as affecting the well-being of mankind as a whole, and it should be defined as a social disease, and then it will be up to those people who are suffering to decide whether they want treatment.

WADDINGTON: I want to make one remark before adjourning this session. I wonder whether we are not dealing too broadly with these topics. It seems to me this Conference is only to consider the critical stages in human evolution. A lot of the things we've talked about in family planning are not necessarily related to the critical phases. Let's take up this question: Do we regard unwanted pregnancy as a social disease? It seems to me it's only a social disease if society is under some stress that makes it so. In a perfectly happy, healthy agricultural society—a preindustrial agricultural society—where women had families of six or seven or eight, and four or five of these were going to die off before they attained adulthood, unwanted pregnancy was not necessarily a social disease. You took your chances when the next baby came.

We tend now to think of it as being a social disease because children are going to be produced that society is not going to be able to look after. The family is going to be too large; there's not going to be enough education; there's not going to be enough food. So I think we should think of family planning and population control, as such, only in relation to the times when they are important, the times of the great transition we're going to make from the wasteful industrial societies of the present to some more stable type of societies of the future.

I suggest that we consider family planning apart from the particular historical circumstances. This is a whole subject in its own right—a very, very important subject—but it's not the subject, in my opinion, that this Conference is supposed to be about. I leave you with that thought; I may be quite wrong.

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HOTCHKISS: My impression is that genetic engineering is somewhat less imminent than some of the other biological questions and also has been considerably aired. I would be willing to defer that discussion and think about procedural questions, such as what this group could do to implement and carry forward any recommendations it might make. My opinion is that evolution and genetic selection in man does not operate highly today, and that genetic manipulation is some distance off, so that social decisions and social questions are far more grave, and man's cultural relations are much more vast, so, lacking time, I would go to the procedural question today.

WADDINGTON: That's rather my view, also. But to start with, I think we need to consider roughly what we have in mind by genetic engineering. We certainly are considering manipulations of genetic material, such as substituting new pieces of DNA, or changing chromosomes, and things like that. But are we also considering manipulations of the early embryo? This is often included in genetic engineering, along with such matters as the possibility of controlling the sex of the next baby. This is often included in genetic engineering, but under a very narrow definition it should not be. Even if we do include such questions, my feeling is that this has been widely discussed by many people and that it's ridiculous to think that this relatively unrepresentative group, sitting around a table, could in a few hours write a better review of the topics than have already been written and published many times before. The major thing one can do at a conference like this is to consider what kind of mechanisms there might be for continuing action of interested academics in these fields.

FRIEDHOFF: Would you include changing the survival of individual characteristics as a result of certain kinds of interventive drugs? Is that the realm of genetic engineering, because it has an impact on the genetic nature of population?

WADDINGTON: Yes, but then so does everything else. The whole of natural selection has an influence.

FRIEDHOFF: Right. That is not part of the definition.

WADDINGTON: I think it would be expanding it to a useless extent to do that. But genetic engineering is a very vague term. It is often held to cover detection of heterozygotes and of protective genetic counseling, and even detection of defective embryos *in utero*. But all of those things have been quite thoroughly discussed, and I don't see that we can add much to these discussions.

STUART MUDD: Would Muller's idea of a sperm pool for genetic purposes be relevant?

WADDINGTON: A sperm bank?

STUART MUDD: Yes.

WADDINGTON: A great deal could be said on both sides, and has been said on both sides, but I don't think in the short time available we have anything to add.

HOTCHKISS: I might make the distinctions that those mechanisms that give one a choice between different sperms or different nuclei, in other words, different parents—make eugenics, sperm banks, and so on, into a means of selecting a whole genus. What is new about the intervention that is visualized is the intervention between a man and one or two or a small number of his genes by any of various means. The reason the distinction is important is that where one would like to have the maximum freedom of choice in a mate or partner, one therefore resists schemes that tend to intrude or adjust the nature of the aggregate of those traits that would make a good mate.

Those very impulses that work in us to resent and resist that type of intervention will be in favor of allowing a man to take his own chances with the injection of a virus or a DNA or something that would give him a chance to change just a small part of the makeup. The very thing that has, I think, held back eugenics is the thing that is working for us in this case. I also make the distinction between genetic intervention when it is used for explorative, curative medical purposes, and genetic manipulation when it is used for more cosmetic or volitional changes, as perhaps sex selection.

I would like to add that the individual and his genes is the individual man and his genome. You can make small modifications in that, but the aggregate of all these are the society's gene pool, and the gene pool is a very useful, very functional, working concept in population genetics. It has almost as precise a meaning as any other term in genetics. The gene pool is, I think, the domain. The lawyers have to consider such questions—medical questions—as family planning in terms of society planning. This kind of thing in reference to gene pools will have to become, I think, more and more regulated as public property.

WADDINGTON: Does an individual have the right to pass his genes on into the gene pool independently? Is this the question?

HOTCHKISS: There are the two aspects—the quantitative and the qualitative. We sometimes think of bad genes and good genes, and we also think of the relative number, because a pool is a quantitative concept in terms of—

WADDINGTON: I think the gene-pool concept is related to the general quality of population that we have discussed. But we've got only a short time, and we must stick to the question of genetic engineering; simply, the control of the gene pool is not really appropriate to this discussion. The question of the control of the gene pool as the property of society as a whole is not really central to the question of genetic engineering. Perhaps we should discuss it in relation to the population policy.

HEDÉN: When we talk about genetic engineering and populations, are we concerned only with human populations? It seems to me that often we talk in terms of human genetics and we very seldom hear a discussion about experiences from animal genetics. In society we are really more concerned with human application of genetic engineering, whereas there can be a tremendous gain, at this stage, that can be reaped from systematic application of other experience.

CANCRO: In the amount of time available I don't think this group will be able to generate much of a statement, because there are only two people who would qualify to generate that statement, and the rest of us would have to take it on faith. I wonder if we might not be able to get around this. From my limited understanding of genetics, the general position seems to be that the environment-gene interaction is such that there may be far more potential and more ease of achieving this diversity through manipulating the environment rather than through a variety of genetic engineering techniques.

If this is true, and because we are concerned with the environment, perhaps we can make a statement about understanding the variety of genetic and environmental interactions that contribute to the quality of human life in various practical ways, so that we can make some kind of a statement-position or position-statement on the importance of the environment, in the genetic sense.

WADDINGTON: I think this will certainly be central to us when we start discussing the environment; certainly, the environment and the interaction between environment and genotype is critical. I don't think we can quite sweep the whole of genetic engineering under the carpet; we ought to do something

about it. One of the most valuable things these working groups can do is to formulate questions that can then be referred to various national groups, to be chewed over at greater length and with wider participation within nations. I think a question we might formulate is: Is it necessary that national regional groups should have mechanisms for discussing the control of possible genetic engineering techniques? Would it be considered desirable, in different countries, to develop the technique for sex determination, and if it were considered desirable, should it be specially funded? If it were considered undesirable, could you stop it from being done if you wanted to?

There is, for example, a certain pressure from the agricultural world to develop techniques for sex determination, and in the poultry industry it might be a very valuable thing to do. But if you've once got it developed for domestic livestock, it's more than likely that it could be developed or would be developed for mankind. Society might decide that this would be undesirable, and I think it's worth asking what sort of mechanisms could be set up for deciding such problems. I do not think that most societies have anybody competent to discuss it or capable of influencing public opinion about it.

MOORE: I have a feeling that the diversity that is subsumed under what we call genetic engineering or eugenics, as well as the state of the art, perhaps, makes it unwise to try to lay down any specific policy recommendations. I like the approach of asking questions that might then be questions for others to try to work on. I wonder whether, in addition, we might not also raise some questions about goals. For example, what is the importance of informed choice, in general, or of encouraging diversity in populations, or of maximizing options for future generations? Are these things that we are committed to as general goals?

WADDINGTON: In the whole of this question of genetic engineering and eugenics the questions are the ethical ones; the technical questions have already been thought of.

SIMON: Part of our obligations might be to spell out some of the nonimmediate implications that might grow out of trying to play around with genetic engineering; I'm very much turned off by it. One implication, for example, occurs to me in regard to the presumed control of gender selection. I can't think of anything more likely to reinforce present gender distinctions: "I want a male child, or I've got a male child; I want a female child because she'll be soft and cuddly;" it's my commitment that we've got to get away from these narrow stereotypical approaches to gender. I think we should start on other, nonimmediate social and psychological approaches to genetic engineering, and stop thinking of it in a narrow, technocratic way: "Gee, we've got this wonderful toy, let's play with it."

Part of our job, in spelling out the questions, is spelling out also at least some of the impinging consequences.

WADDINGTON: But I don't think we have time or people to do that job here and now. To cover the whole range of topics, of which genetic engineering is only one small part, we have only two working days, and a not very large group of people.

The problems raised by Dr. Simon are the sort of things that regions or nations should have bodies considering, and they should then organize proper discussions. You have raised one possible consequence of gender selection; there might be others. The younger generation, at the moment, seems to be doing its best to reduce the difference between genders, and parents may think:

"Let's have a nice, strong, male boy." They may have a boy, but he may behave more like a girl than any of their daughters. The young generation can frustrate that sort of thing. I'm not saying this very seriously, but I am saying that all these questions, such as Dr. Simon raised, are quite complex and can't be thoroughly discussed and certainly can't be conclusively answered in the time we have available. But I do think it might be valuable for us to say that there are many such questions that are fundamentally ethical questions and not technical ones and that should be publicly discussed by responsible bodies all around the world.

One of the questions we should ask ourselves, for instance, is: Has anyone the right to select the donors to a sperm bank? At the present time, doctors who carry out artificial insemination presumably select the donors. But doctors are used to facing difficult ethical problems and acting on them. They have to. It's part of their profession, and presumably in this field they are already doing so. And, I think, in the medical profession there have been many discussions on how this should be done and how one should select donors.

ERAJ: I do it myself, and we are still looking for genetic engineers to tell us what is the best way.

WAKEFIELD: Somebody proposed that in order to satisfy the desire of women to have children and of men to sire children, all men contribute sperm to a universal bank. Thus, the men could be relishing the idea that they were siring children, and all women would have children by artificial insemination from the gene bank, and no one would know who else was doing what. This might simplify matters.

WADDINGTON: But not enough is known to trust that. If you inseminate animals with mixed sperm from two different sires, it very often turns out that one sire is much more effective in producing fertilization, because of rate of movement of sperm in the tract, or something similar.

STUART MUDD: Would you want your daughter to have a child that way?

WAKEFIELD: If we could judge whether what's in the bank is good or not it would serve several purposes. I wouldn't care.

SIMON: I can't see why society would want to invest 33 cents in that plan. I can't think of a single positive benefit.

HOTCHKISS: We haven't made any attempt to define the sperm bank. I would say that the first thing that comes to mind is the restorative aspect; that is, making up for deficiencies. For example, a diabetic has to have insulin from I don't know how many cows that are slaughtered, among other things; if some small part of the cells could be given the ability to make insulin, one important problem would be solved. There are many other examples that you can adduce, and I think they will be acted on when they become possible.

FRIEDHOFF: One of the things that I'm reacting to about this is that most of the other issues we're talking about—starvation, population control—pose immediate crises. Perhaps I'm wrong about this, but I don't think that, either in terms of the threat or the potential, this is of the same order of magnitude.

STUART MUDD: I would agree. I think it's too bad to treat this subject frivolously, because Herman J. Muller, in the third volume of the World Academy series, The Population Crisis, gives a profound discussion about what the real threats are. I think—with all due respect—that we don't have the collective competence to formulate anything very useful beyond plans that are ongoing.

NG: I want to pursue the point on the advantages of a sperm bank in rela-

tion to this whole question. The issues raised are that having children today is a very haphazard thing, yet we place into it something of the utmost importance, which is our desire for immortality, and, at the same time, we leave it to chance to decide what our offspring shall be. The day will come, perhaps, when we will have more knowledge as to which gene controls what aspect of creativity, and there is the present danger that the quality of human life—as has been expressed—is going down gradually because of overprotection. We are harboring an increasing pool of diabetics; we are increasingly harboring kidney disease, and other kinds of diseases that may be genetically based. The time may come when if there is a sudden stress placed on the environment—and "stress" I put in quotes—it may be environmental stress, when resistance is so narrow that the human race could be wiped out.

The other possibility—although raised somewhat facetiously with regard to a sperm bank—is that a young person, for example, who is not married but who may be contemplating having children years later, could be dating for the future, so to speak, in the sperm bank. One can envision a society where the values have changed in such a way that the decision to have children in a predetermined way would become a very creative act. A man and woman would sit down and decide: "Yes, I'd like a child who is disposed to be athletic, and another child of the opposite sex disposed to be a violinist."

WADDINGTON: These are not in the slightest very immediate questions, because even if you select a given father, you're going to get only a random sample of his genes. You can't tell what particular sperm you're going to get from the individual.

MOORE: I'd like to pursue that point for a moment. Although our group can't really formulate all the answers here, we have a responsibility to call attention to the range of the issues that we see. As a lawyer I'm not familiar with just how seriously we ought to take these various problems, but they sound serious, indeed, to me. And one of these is the very profound question of whether the human race is going to go downhill genetically because of the lack of selection factor.

A second may be the issue of informed consent in the use of a sperm bank or artificial insemination program. What is consent in that case? Consent to the mother, for example, and consent, perhaps, to the father? What's informed consent to the future child, to the offspring, in a situation like that? In reading a popular magazine recently, I encountered a discussion of how persons might be able now to choose the sex of their unborn children. It seems to me that this raises very serious policy implications, and it may lead to major sex imbalance; it may require some kind of governmental intervention, and the desirability and advisability of that kind of intervention is a serious question.

It seems to me that there is a whole Pandora's Box of issues that are raised, and at least we ought to call attention to the need for some kind of continuing study.

CANCRO: I didn't mean earlier to sweep genetic engineering under the rug, although now I'm not so sure that I don't want to change my position. What I would like to do is to place it in some sort of perspective because it is not an imminent problem. I think ongoing commissions could do an enormously important educational job in clarifying what genetics is *not* all about, because people still look at genetics in a deterministic way: if you have a particular genotype that determines the phenotype; it's a one-to-one deterministic linear model. There's an enormously important educational job that geneticists have to do.

Another thing that geneticists could do, and this could be a charge to these commissions in addition to their educational task, is to set up procedures, means, structures that will make certain kinds of decisions possible as the information reaches the point where we can do something about the genotype as a component in the ultimate outcome, where people can indicate their desire for a certain kind of genotype. Who will make these decisions? Who will carry them through?

In discussion with a colleague recently, as I briefed him on some of the things that geneticists have in store, he said that these would be the last people in the world that he would want to see control these decisions, because he wouldn't want engineering-type mentalities to make such decisions. Therefore, I think it's difficult to say who should have an input into this decision-making process. Should it be only geneticists? Should it be only scientists? Should there be much broader representation from a variety of other disciplines and nondisciplines? These are some of the questions we can turn over to such commissions to dispose of.

SIMON: In our Western society there is the belief that science is good; let science do it. I think there are other ways of handling it. We talk about all kinds of changes, and we still continue to have a very stable, static concept of man and his social relationships. There are fundamental things, like different modes of family life, and a number of experiments are going on about these different modes of family life. The questions raised about the genetic propensities to maladaptation should really be handled, because there's nothing that is instinctive about man's need to reproduce, or woman's need to experience motherhood biologically. This is much easier to tamper with than genetics, and indeed, the society that would accept this kind of tampering is well on the way to having transferred its values, and it's very problematic how this will be engineered. I think that the problems that need *social engineering* are more pressing.

WADDINGTON: I think the only things that are at all immediate are things like being able to determine gender, which you could in practice do now if you had abortion laws that allowed you to abort a fetus of the wrong sex; you could make quite certain what sex your next baby would be. It's things of that kind that I think need studying at present. I think the longer-term effects on the genes is such that nothing happens for many generations.

SIMON: There are psychological implications even in that. One of the nice things about our present inefficiency is that it protects us from some of our worst impulses. Can you imagine the kind of personalities we're talking about that are so hung up on the gender of the prospective child that they would abort one or more fetuses in order to insure that they would have a male child? Anybody who really wanted to do that I would really want to deny maternity to.

HOTCHKISS: If it happens on the second or the third child, though, and you've had two boys previously . . . .

SIMON: We go back to the persistence of these terrible hangups. They're far more dangerous than the number of diabetics we have.

CANCRO: We have to take some responsibilities.

HEDÉN: I think that one important aspect of this problem is extension of genetic diagnosis. Isn't it very likely that as research continues, a variety of

diseases *will* be diagnosed before birth? The question is, should one not stimulate that type of study? I am thinking particularly about gout, which is a metabolic disease, and which seems to be related to gifted people. This is a case where obviously a direct decision would have to be made. This may be a unique case. There are other cases like that, where if you make a genetic decision you might lose something. What are the factors that don't exist in this society but which might exist 200 or 300 years from now?

WADDINGTON: These are problems about which we can't possibly lay down any answers. There have been suggestions that schizophrenia is much commoner in families with brilliant individuals, and many notable geniuses, such as Beethoven, were schizophrenic. So some selection against certain apparently bad genes may very well work against extremely valuable characteristics, too. But this sort of work *is* going on and *is* being considered and discussed thoroughly. Such metabolic diseases as phenylketonuria, in which individuals are absolute imbeciles unless you can keep phenylalanine out of their diet, can now be diagnosed at birth, and we certainly will be able to diagnose it before birth in the not distant future.

This is not genetic engineering; it's ordinary advanced medical practice. When we come to deal with it not by continual dietary control of the harmful amino acid but by in some way giving the cells the genetic capacity to make the missing enzyme, which is what causes the metabolic disorder and the imbecility —this may become technically possible in the not-too-distant future, but it doesn't seem to me that even this kind of curative approach would raise any particular problems. It would be a rather more subtle form of medication.

HOTCHKISS: The detection of a heterozygous person with dominant traces is not at all difficult and is going on as a natural part of human genetics. I really question whether it should be stimulated.

WADDINGTON: I don't think we can go on discussing general human genetics indefinitely. I would like some ideas for anything we can usefully propose to the conference.

CALHOUN: I would like to suggest that we include a proposal to continue the examination of this issue as a part of an assembly of issues that we wish to forward, more or less to define the scope of whatever the continuing commission would be involved in.

WAKEFIELD: We have talked frequently about interdisciplinary matters, and the whole question of serious policy matters really needs to be considered in something like the determination of sex.

WADDINGTON: This is a suggestion for continued discussion of these topics at other disciplinary levels.

STUART MUDD: I think we shouldn't give the impression that practical possibilities in this field are endless and that we should have an ongoing discussion in other abstract terms. I think one of the things that has been unfortunate is that you read so much nonsense in the literature; there are so many expectations that are not going to be realized; we want to work in the other direction.

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HEDÉN: In discussing the question of delivery of health care, I would like to emphasize that there is a need for expansion into a much larger group of individuals who can take care of the interindividual contacts—family advice, health advice, and so on. This, I think, is important, and perhaps we should try to tie in with other discussions of such problems as the situation in the

postindustrial society, where one must find jobs for a very large number of non-science-trained people. Certainly, in the postindustrial society there will be a need for a lot of advice in this area.

I think we more or less can agree that medical ethics should be extended beyond the individual patient to the suffering individual elsewhere. But, in our earlier discussion, before the stenotypist arrived, nobody really expressed the idea that the medical profession should take responsibility for others than individuals—for groups of individuals. What I mean is that the individual and individual relationships quite obviously count when it comes to the doctor-patient relationship, but the doctor should also have a responsibility to incorporate suffering individuals elsewhere.

Then there is a question about cost vs. benefit. Of course, the thing that must be considered is the time available to the doctor for contact with the individual patient; this, of course, determines what the interpersonal relationship can be. In many societies, particularly in developing countries, but also in many highly industrialized societies, medical care is such that only a few minutes are left for the doctor to communicate with his patient. This certainly makes the doctor and also the patient lose a sense of touch.

I also think that in our discussions today we should take up the question of the overuse of drugs.

SIMON: I wonder if we could agree on the very general notion that many of us are moving toward with some resistance: the redesign of delivery of services and the very concept of the profession in a professional role. Training and professional recruitment really must be self-consciously viewed by society, and there must be some kind of collective decision that we should or shouldn't, or can or cannot tolerate inheriting what has evolved from the past, which really depended on a command of technology and chemistry, and which now seems almost prehistoric. The notion of the self-conscious radical redesign of the medical profession's services as a total complex is really a major obligation of all societies, both developed and underdeveloped. This cannot be left for the medical profession to solve for itself.

SAGER: Within each unit of the health system, there should be maximum self-determination by the professional subgroup represented, who are closer to some of the more immediate, moment-to-moment problems. Radical designs can be made, I think, only in broad brush strokes. Medicine is just part of the health delivery system, but it should have a lot of say on its part, just as should social work on its part and architecture on its part.

HOLLAENDER: The people who would provide some of the medical services that the physician hasn't time for and that are really not necessary for him to perform should be considered. We should note that the profession of midwife at one time fulfilled exactly this role. In many of the less-developed countries it is quite urgent that we encourage professions of this type, because they can perform a lot of the services where the physician isn't really necessary. I think that preventive medicine and small, simple aspects of medicine could be left in the hands of such people. The recommendation that patients go to a physician could come from professionals of this type. Their ethical standards usually are very high. They are well trained and fill many of the roles for which we are now groping around for somebody to fill. In rural areas, this is how one often gets his first help in case of illness. Also, I have worked in Appalachia. Even now, midwives there are fulfilling a very important role.

SIMON: There are suggestions for a speedy cross-disciplinary collaboration,

In the underdeveloped countries, one of the major problems is simply the vast social distance between the doctor and patient, who often really don't understand each other. One of the functions of the midwife, in many ways, is that she tends to narrow that gap. She is very much like, and comes from the world of, the people who need help. For example, the design of medical services for underdeveloped countries should perhaps include not only the Western-trained physician, but the anthropologist, who at least could help understand what the problems of the gap between the patient and the physician might be. He would play a crucial role in the design of the services and also, perhaps, in training the physician.

WADDINGTON: I think we will need many more professions playing positive roles in more vague areas like, for example, keeping weight within reason, or all the various ways people are going to use the extra leisure that they are presumably going to have in the industrial world. In the developing world, of course, the whole question of parasites arises, which is one of the major problems in much of Africa. A lot of this could be handled by health advisers of various kinds, who would be broader than the midwife, but of the same professional status.

WAKEFIELD: In agriculture, one of the most successful programs in the United States, now being developed all over the world, was the county agent. They advise on simple problems of crops and how to take care of animals. I have just been to Colombia, and they are trying to copy this pattern of the county agents who go around and know all the people in the area and can talk to them on a personal basis.

HEDÉN: We seem to agree that this is important. Certainly, it is important that we recognize that the medical profession, in a sense, in its isolation behind very complex apparatuses of different types, is inaccessible and appears as a sort of a robot to a large part of the population.

WADDINGTON: I think the parallel with agriculture is quite useful, because this type of approach has been well organized in the institutions, not only in this country but in many countries. In Britain, we have an advisory service that is separate but allied to the agricultural research service in New Zealand and Australia. This is a very highly developed service, with people who can tell you how to handle your pastures and cattle, this, that, and the other. There we have institutions that we can point to that other professions have developed.

HEDÉN: With regard to the cost-benefit problem in the more technological sense, what is your feeling with regard to such things as the expansion of psychopharmacologic drugs, which may make the patient much easier to handle for the psychiatrist, but which, in certain situations, pushes him away from personal contact? There are activities in many countries to compensate for that, but I doubt whether it is enough. I think when we shove something under the carpet with psychopharmacological drugs, it is not good.

HOTCHKISS: Could I ask a general question? We probably aren't going to cover all the items we are intending to discuss. I wonder if maybe we could go through them and have the group decide which it feels is most important and wants to take up.

HEDÉN: Yes. One point that we may have covered already, in a sense, is preventive medicine, the emphasis on preventive medicine and things like pediatrics, and the relation between the pediatrician and the psychologist to help bring to fruition all the qualities in the baby. This is certainly important, and I guess that we all would like to see greater cooperation. Then we might consider fads and fashions, like heart transplantation, about which I have a rather glib opinion, in a sense.

We have the problem of medical engineering. There are a lot of things to which one could refer, for instance, new techniques in approaching questions of artificial kidneys and, on the more distant horizon, artificial livers. Then there is the question of handicaps, ranging from the physical handicaps to social handicaps. And, there is the difference in national priorities. These are our discussion points. Have you any preference?

HOTCHKISS: I have a general comment, and it refers to Dr. Simon, who was saying something about this earlier. I rather resist the suggestion that we are in a position to speak of a revolutionary approach to redesign. On the other hand, I would like to move in that direction, too. It is the most common, trite, and boring thing in all committees and commissions to say, "This is a time of change; we're at the crossroads." But if you are sensitive to current events, you are also aware of the changes and aware of the crossroads. What we can do, if anything, about structure, is to try to analyze and describe, as specifically as we can, what those changes are and what those choices are that are now being made.

In a group as small as this, representing a variety of people, all we can do is say that these questions seem important to us. If we believe that we have some kind of average intelligence representing a larger group, then we may be entitled to be listened to and we can discuss these questions.

Every ten minutes we ought to stop and ask, "What are the questions we're going to pass on?" and then we can go right through the whole thing. Maybe if we will take ten minutes for some questions and less for others, this will work.

SIMON: I quite agree. I would try to truncate the process slightly, out of necessity, but we could develop the language of crisis to justify it. The real point of view is the fact that one points, with or without prodding, to every crisis and says, "Let us not become victims of history; let us decide what we need and what we have, and then self-consciously try to program our medical future, and not as we do in many, many other areas, simply take the dead weight of the past as any kind of imperative principle." That is important for all of us in considering the ranges for the future.

SAGER: There seems to be a common theme running through all of this. What we are looking for are ways of maximizing health by increasing the availability of medical knowledge and experience, and doing it in a way that does not lose the individual and personal touch. Perhaps an underlying feeling that should be part of any document we submit is the strong emphasis that, although there are many technological methods and many devices that can be used to extend the availability of medicine, we want to find a way of maximizing health, but not at the expense of the personal element, nor by depersonalizing it.

I suppose one extreme example of this is the computer-medicine programs now being developed. They carry with them, you might say, the seeds of this great problem, because of the possibility of universal diagnosis of all sorts of ailments. At least, this is one of the aims. It is considered that computer diagnosis will take the place of the physician in some very important areas and will make available diagnosis around the corner to find out whether you have diabetes or not. But how do you carry with this the personal touch? I think this is a major problem.

SIMON: Part of the romance is that this is becoming a notion that we need the personal. I am not really sure of that. There is, for example, the disappearance of the corner grocery store, the man you could trust. We found the supermarket impersonal but offering us many more alternatives. It makes the shopping process much more efficient. There is access to a multiplicity of products. We suddenly discover that it really left room for the personal thing in many other areas. I am not sure that in the medical world we need necessarily bear the cost of personalizing all of it. Man is pretty adaptable. We learned to shop in supermarkets, and we can learn to shop in the supermarkets of medicine as well, without knowing the faceless person who packages a piece of meat. There may be moments, indeed, of human crisis when you want a warm, reassuring human being, but the medical profession hasn't been good at giving us that, anyway.

HEDÉN: Which is better?

SAGER: I couldn't possibly disagree more.

FRIEDHOFF: I don't want to run this into the ground, but the fact is that medical care has not been applied that way in the past. It isn't a question of changing it. There has been a good deal achieved for and by many people in our circumstances, but not by most people getting medical care. It really isn't a question of changing; it is a question of how can we supply medical care to the people who have never had any. That is the critical aspect. It is not the refinements we require from the physician; I think we're going to get them, anyway. It is really the other problem: how are we going to optimize the application of medical care to those people who have had very little or no medical care? I think they constitute a large percentage of the people in this country.

WADDINGTON: In the past, a large majority of people did get paramedical care from somebody like the midwife or the chemist. In the old days, the chemist in the town where I was brought up prescribed for you.

HOTCHKISS: He was a medical social worker.

CANCRO: There is a difference in the direction toward which you might want to plan for the extension of the health care delivery system to those who have not had the benefits. One can lean more toward the supermarket approach that Dr. Simon has described or more toward the more personalized approach. I think one has, at some point, to get into a cost-benefit approach to this problem. It may be a two-step operation. We may say, "Well, ultimately we would like to give type-C care, but we can't do it yet; we'll have to start with type A, which is better than what you have, and in ten years reach type C."

WADDINGTON: But, if we raise the question of the possibility of a sort of paramedical-medical-social worker or health social worker, aren't we raising the possibility of getting the best of both worlds? You get the personalized care in your daily life, and you get into the supermarket only occasionally which is fine for diversity, but many people will find it quite alien. This is really part of the dehumanization of urban living: you no longer gossip with the shopkeeper or exchange news about the love affairs of the village.

SIMON: He also doesn't gossip about you.

WADDINGTON: We are so free we are alienated. Nobody is as set free as an alienated person. We are totally free, and people don't like it.

SIMON: White and Parker, at the Department of Sociology in Chicago, described urbanization in the same language. They both said the city had two gifts to offer—freedom and loneliness. This may be one price we have to pay.

I get very suspicious of terms like dehumanization, as if it were a fixed term. I think humanity is adaptable. What we are talking about are value preferences. I'm not sure we could argue other than the vagaries of our taste.

WADDINGTON: I don't think we are acting on our autobiographical experience. Personally, I rather enjoy the degree of freedom in the city, but we're acting on expressions of a very large number of youngsters who claim they aren't getting enough contact; they then set up their own community living settlements with all sorts of systems that are obviously aimed at getting the values, which are not freedom and loneliness, but are community.

SIMON: By the way, part of the problem is that we have corrupted these young people hopelessly. All their ideologies are really of our generation. Their leader, Herbert Marcuse, for example is in his 70s, and Paul Goodman is in his declining 50s, and even Friedenberg is in his 50s. Leonard Cohen is about 40.

WADDINGTON: *They* don't go off in communities.

SIMON: We are the ones who supply the image of a plan without really viable alternatives. We give them the language of alienation. We may actually have invested it for them in many ways.

HEDÉN: We are a bit sidetracked, here.

CALHOUN: I think that the cost-benefit point is an essential one. Dr. Cancro said in a cost-benefit analysis that we can give A now but we know that C would be better—but we can't do it. We have, here, the issue of rising expectations that can't be met, that relate closely to the image that a people have, or a class of people, or nations have. I don't want to get overinvolved, but I think that our conceptions of what may be and what is possible are far out of line with what is actual now. We have to integrate these expectations. We want it now, but we can't get it, and this causes confrontation and conflict. I don't know how we're going to resolve it, but I think it is a core issue, here, because we are defining problems. If we define them with any adequacy at all, we will say that we should set our goals a whole lot higher, even though they may be difficult to attain.

I don't want to be too philosophical about this, but it is one core issue in solving the difference between the anticipated and the realizable, and yet making something out of the nonrealizable part of our image. I don't know how we do this; somehow this relates to a very intriguing statement made by Dr. Catlin: he said that the right book at the right place to the right person has more effect than 100 commission reports. He was speaking of the interacting of events. He was, in a way, speaking of charisma, which has not been brought up here at all. How do you program for charisma, or program an idea? How do you get it out to the public in the right way?

We are meeting here in New York City; there are some plans that will be offered here, and I don't know what they are, but we will have an opportunity. We won't be here in six months to make some statement crystallizing some viewpoint or other, something that has some flash to it. This is not scientific; we have to realize that we are living in a political world.

Despite Professor Hotchkiss' comment, we *are* living in a time of change. I think we are at an unusual stage, and at an unusually critical point. Things are different, and we can't worry about the details of some of the things that will take 15, 20, or 25 years to bring to fruition. Of course, we are concerned about these things, but there is the other issue of trying to make some impact on the scene or not getting involved at all.

MOORE: I am not sure that the issue is personalized versus depersonalized. I think we might simply state that one of our goals is at least the opportunity for personalized approaches to health care by those who want it. I think we would want a maximization of free, informed choice and want to recognize that all health care does not necessarily have to be aimed at a grocery-store rather than supermarket approach but that there is at least an obligation to have a significant portion of health care aimed at the former, so that the individual who wants it and needs it can buy that approach.

That brings us to the second issue, the conflict, if there is one, between short, intermediate, or long-run goals. There is a cost-benefit problem of health care for the masses; if I had my choice between no health care and depersonalized health care, I would have no hesitation about accepting the depersonalized health care. But we may or may not have that choice.

HEDÉN: Of course, we must realize that we can't fail to touch on research priorities or priorities in planning. Certainly, we cannot provide ideal medical care to everyone. If we can't, we may have to turn to a supermarket sort of transition phase before we can catch up.

One thing that many people who are not in the profession underestimate is the amount that can be done with regard to improvement of medical technology. There is a lot of effort going into heart pumps and very sophisticated gadgets for all sorts of things. I am not talking about that. But if you count the number of noses that are actually bent over automating devices that can be used, for example, for enzymatic diagnosis, it is very small.

Essentially, one could extend medical care—preventive medicine—not by expanding the medical profession but by putting some effort into the engineering field or the science field directed toward specific areas. The advances made in microanalytical techniques to determine different enzymes are remarkable, but these techniques are of a relatively sophisticated nature, and only about eight or ten are automated completely. Those automated techniques do not exist in many parts of the world. People have the notion that in developing parts of the world what is needed is a very simple sort of approach to many problems. But I think also they need even more sophisticated screening techniques than we now use. Maybe there is an area where one really needs immunological screening techniques. Some of the techniques already exist, but they are not applied in the developing parts of the world. This sort of mass medical care is something that I think could be expanded a great deal by entities outside the medical field.

SAGER: Why don't the pharmaceutical companies do it—because it is not profitable?

HEDÉN: They, of course, are concerned with drugs. But this is largely a question of engineering and biochemistry. There are, for instance, all sorts of strip tests coming out, now. You dip a piece of filter paper prepared by ion exchange into a sample of urine, and you detect whether there is sugar. There are many being developed, but not at all in relation to the need. There are a tremendous number of things that could conceivably be developed. There has been a lot of speculation, but very little done, remarkably little.

SIMON: Part of the problem is that we each have a different knowledge of what we're talking about beyond the details, and we slip from one level to another. There are three kinds of things for each of the levels. One is a question of social environmental control, simply that intervention without

respect to specific data on specific human beings that deals with aggregates in terms of their aggregate properties. This involves partly the medical professions, but also mechanical engineering, chemical engineering, architects, social scientists, economists, and so forth.

SAGER: What do you mean by "control?"

SIMON: The fact that you simply limit the pollutants and redesign housing or redesign all kinds of things aimed at improving people's health status because you have altered their environment. This is perhaps the broadest level in many ways in terms of dollar investment of all countries, and the most efficient. You learn to keep people away from drinking unsafe water, and infant mortality goes down. You don't have to concern yourself with individuals.

HOTCHKISS: You're talking about the entire area we're going to discuss this week.

SIMON: I know, but in each one of these, as we talk about them, sometimes we move up to this level and sometimes we get down to the question of primary prevention, where we really are concerned with individual attributes. We need one kind of system for it. With different kinds of specialists, there is another level, which is really the "crisis intervention" level.

Now we have to confront ourselves with the specific, unique human being, and somehow the role of the medical practitioner is growing as we move down from social environmental to primary prevention to crisis intervention. Primary prevention can be computerized in a way that I suspect crisis intervention can make less use of. For example, middle levels respond now to individual records. You simply require of every citizen that he come into the computerized place and take X number of tests, which we can do technologically very cheaply. We have continuous medical records. We *can* have the computer capacity for it, and then the physician in the crisis intervention situation has a medical record to an extent he never had before, and, more important, the computer can make certain judgments. If, for instance, a drop in weight goes beyond one standard deviation from a trend line that has emerged, a red light goes on and you get a little IBM notice that may say, "Do not bend or tear," but it also says, "Get yourself down here! We want to check you over." This is the only primary prevention that makes sense.

HEDÉN: When the individual is not sick, we don't need individual, face-to-face contact, but we must make a clear distinction between, on the one hand, treatment of the sick person and, on the other, prevention of disease, which are really two quite distant things.

CANCRO: Acute illness and chronic illness are different. Chronic illness may not require the kind of personal care and intense physician attention that acute illness does. If you need an injection a week, probably you can train a person you live with to do it. There are many kinds of chronic care, especially in physical treatment, where paramedical personnel can provide it just as effectively as anyone else. If we want to go into this in depth, which I am not sure is our mandate, we have to make such distinctions.

HEDÉN: I think we should touch on another aspect of health, and that is the difficulty for the medical profession to integrate the chronic effects of all different influences, by which I mean chemicals of all sorts, food additives, and everything under the sun. One can certainly detect what the individual

thing does in animal tests, but what is the compound effect? How can we approach this?

HOLLAENDER: It is a very difficult problem to detect, for instance, the effects of moderately polluted water. It is bad for our health, but there are no data available. This is speculation, purely. By moderately polluted water I mean water that you get in many wells in many cities, nowadays. But we don't have any data, and to obtain such data is so complicated and so expensive that we could do it only on epidemiological bases, and observe millions of people. Even then it would take 10 or 20 years to obtain such data. And, this is worldwide. Somebody has to decide so that we can speak with more authority if such questions come up.

In regard to chronic exposure to radiation, there is an unavoidable level of cosmic radiation and other radiations. The controversy going on right now is about the placing of reactors in populated areas. I think if it is planned carefully and really carefully controlled, one could say one could set up fairly safe conditions; even then, however, I wouldn't recommend putting a reactor right in New York City, or any heavily populated area.

The area we are particularly interested in now, and which urgently requires very detailed investigation, is the action of chemicals in regard to genetic effects. We know that chemicals will produce mutations. We know, at least, that certain ones have some kind of relationship to the effectiveness of nucleic acids, but we don't have any quantitative data in this area yet. This field has been developed only in the last 25 or 30 years, and radiation studies have been going on, as far as genetic effects are concerned, for almost 45 years. But we do have methods, now, to detect chemical mutagens. They are not perfect, but they can be used in a quantitative way. We have those methods now, and we will hear a lot about this in the next two or three years, because this will become a standard requirement for testing.

We don't have much data or information yet, but we know that a low level of some of these compounds has long-term effects. I think it would be really necessary for this group to consider the matter. One could discuss it in more detail and then suggest some recommendation that tests be set up for checking on chemicals, because we cannot afford another thalidomide disaster. The next would be a much more serious one. It would be a genetic disaster, because it would affect future generations. I wonder whether this whole question of chemicals and radiation and different factors in our surroundings that have genetic effects shouldn't be discussed in more detail, later.

CALHOUN: Since you raised the question of chemicals, I would like to mention a rather insidious problem. It just developed in my experiments, and I have followed it up. It is the kind of thing that can be very devastating. This particular example involves vitamin A. By accident, I found in observing rats in one of my social studies that there were some pathologies, and I figured they were from vitamin A, but I didn't know what they were. I first got in touch with one of the people who are the most knowledgeable in vitamin A chemistry, at Eastman Kodak.

This person said, "Send me some livers of the animals." I sent them, and he analyzed the material and immediately got back on the telephone. "What have you been supplementing these with?" I said I hadn't been. He said, "They have 45 to 60 times the normal circulating level of vitamin A."

We had gone into an experimental program, and I had seen some very strange social behavior. What we found was that the Purina Chow people were supplementing with vitamin A without telling anybody. The level they had was what a lot of people are getting now. In rats, this was an extremely potent tranquilizer, or a kind of tranquilizer. It prevents animals from perceiving complex situations or engaging in complex behavior. They quit reproducing; they don't fight; they don't do anything. Beginning at the time I found this, all the companies in the country started putting vitamin A in milk. Any kid who was taking two quarts of milk a day regularly should in time reach the same levels.

If this is, in fact, happening, and I don't know whether it is (the supplementation started in 1963, then it went on on a very wide scale) it is much more important than all the radiation business, because society will collapse. It may be already here. I don't think we have had quite enough time for this, but it is this sort of thing for which our ability for screening is limited. We may raise an animal in a cage or something like that, but it is not the real-life situation. We are not testing the right parameters. There are some very insidious things that can happen chemically, and this is just one example of something that may be in the offing and relevant to the consumer.

FRIEDHOFF: I think Dr. Calhoun raises an issue of considerable importance. When we talk about the effect of environmental pollutants, we talk about growth effects, such as the effect on basic cellular metabolism. I think that behavioral phenomena are often much more susceptible to investigation compared with changes in levels of lead in the air, for instance, or radiation, or chemicals, particularly when applied in early life. They can have—and I think there is increasing evidence that they often do have—subtle effects on behavior that are not measurable by the usual pathological considerations that we ordinarily make. We could have, in terms of the effect on human behavior, very drastic effects on future generations.

HEDÉN: I also understand that several of the agents may affect the aging process, which is certainly something we don't consider in the ordinary context. I am, of course, worried by the fact that we may have very profound knowledge about chemicals or radiation or something but know very little about the combined total effect. Can we make certain that research in this area and accumulation of more knowledge expands and continues? Isn't it likely that in this area, as well as every other area, there will be a situation where we will be hit by repercussions and will not get the knowledge we need?

SIMON: I think this underscores the need for mammoth data collection, both for primary prevention and otherwise. We do have the technological capacity for this kind of data gathering. It ought to be an important mandate for all society now to move toward systematic global data recording, which would now include, I think for the first time, moving beyond the physiological to standard behavioral measures and an interest in primary prevention and continuing evaluation of the collective.

CANCRO: There is incredible resistance to this.

WADDINGTON: You could get something simply by epidemiologic collection of data, but I think quite definitely that experimentation in these fields will also be needed. The question of synergistic effects, for example, of lead and an extra bit of vitamin A is going to need large-scale experimentation. They are world problems, and it is my belief that the scale of experi-

mentation to determine the effects of low doses is probably best done on an international organization scale rather than on a national scale. Even in the relatively simple case of the radiation effects on gene mutation, no country in the world but the United States has been able to afford even partially effective experiments.

HEDÉN: I support this very strongly. I think this type of effort is really something that must be considered very seriously.

WADDINGTON: As biologists, I think we could feel sufficiently confident not to merely ask a question but to make a recommendation. I believe we should recommend that there is a need for international institutionalization on a large scale of experimental work on the effects of low doses of potentially deleterious substances and their synergistic effects.

HEDÉN: There is, of course, a whole range of diseases about which there has been more or less convincing evidence of a relationship to the amount of different trace elements in the environment. There was some research on osteoporosis in cats in America, and I think a relationship to cadmium was found, but I am not certain. It was one of the rather unusual elements. There may be many other things that we know little about. One would like to see data banks, which are available now, focused on epidemiology, not from the infectious-disease point of view but from toxicology.

HOTCHKISS: I think our recommendation would take the form of a question, because if there are potentially a large number of toxic substances, we still have to have an educated guess as to which ones are worth investigating.

CALHOUN: But I think we can call for these educated guesses. First of all, I think Dr. Hollaender may even know what some investigators have already suggested. I think we should call attention to this type of problem and to the ways of getting at the educated guesses. Wouldn't that be logical? The focus that was raised here on synergism may be a primary focus. It has reflections in the physiological and the social areas, where it raises the question of complexity and co-action. This might be one point of focus of our various problems. We will never answer all the questions if we reduce them to a single-factor type of problem. But certainly in this country, the awareness now of the ecology and its interrelationships is a very good one. I don't know how it is in the rest of the world.

WADDINGTON: There are two aspects to this, but I don't know whether it is worth distinguishing them. One is that we have, of course, cleaned up the environment to a great extent by getting rid of such diseases as plague, yellow fever, and malaria, almost completely. Some of the synergisms that have been mentioned have been with us from the beginning. There will always be damp dwellings with aspergilli, and leukemia-producing viruses. But that is the next stage, cleaning the environment medically, which is more complex than the simple things we have done already. Therefore, we need these big research programs on synergistic effects.

We are also, of course, adding pollutants to the environment, such as atmospheric lead, which certainly wasn't common in medieval times, presumably, although it was said to be one of the causes of the fall of Rome, where they were using lead cooking pots.

But there *are* new synergisms coming through the technological advances. In a way, we might be asking for a continuation of the process of cleaning up these natural hazards of the uncontaminated environment, as well as dealing with new contaminants.

HEDÉN: Should stress factors be a consideration?

CALHOUN: Yes, and stress could be couched in synergistic terms; we could try to develop terminology along the lines of synergistic pollution and pathology.

HOTCHKISS: This specific type of synergism is analogous to certain agents at different stages of life, such as at puberty, maybe, or times when hormonal changes are going on. I think that ordinary medical considerations already take into account this particular susceptibility at different ages. This is true, also, of the genetic deficiencies relating to infancy, when so much of the tissue—especially its organization—is laid down in embryo. This is the time when some of the genetic metabolic deficiencies take their worst toll. We have a particular temporal susceptibility as well as the interactions to consider.

This is, however, better taken care of in other aspects of our report, but I think it would be well for us to bear it in mind.

HEDÉN: This ties in with education, because one of the fundamental focuses for biology education is the child-rearing and childbearing years, the nutritional requirements of the baby, and the overall psychological situation of the baby—something I think well worth a special emphasis, if one is going to think in terms of the impact of education on the public.

CANCRO: Let me make a distinction that I think would be useful when we speak of education. There is an enormous difference when one talks about the impact of an educational system, of getting children to understand biology and physiology. This has a long-term impact. The time frame in which that impact will be seen is very different from, for example, the American Cancer Society's educational programs, which are geared toward "examine your breasts right now, and if you feel something you didn't feel yesterday, take yourself down to the doctor." That is really an action program. Even though we call it education, it is really much more action-oriented.

I would recommend that we not lose sight of the action concept, and that some of the broad recommendations we make, or the kinds of inputs we want to have, would be that things need to be done above and beyond introducing new courses and new curricula, which will take a long time, because we also have to face short-term problems. While our short-term solutions may not be effective in terms of the longer-term goals, they still may be a way to hold the line until the longer-range solutions can become operative.

HEDÉN: Does everybody agree on that point? I think so. I wonder whether we must touch on another point: We say there are certain things that are important, but this raises a question of the money's having to come from somewhere. There has to be some balance. Also, should we say something about the impact of overstudied areas and the fact that they actually detract from a number of other areas that should be considered?

SAGER: If it can be framed in some way acceptable to this group, I think it would be an enormous contribution.

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(The earlier part of the next session was devoted to an extended discussion of various draft statements considered by the group. The transcript, therefore, begins after the start of the session.)

CALHOUN: . . . I would like to raise the question of spelling out in some way, or discussing institutions and strategies; how do you assess institutions and strategies for meeting such things as the population problem or the medical problem? If we just say "human rights" and "we're all for motherhood, and we're all for education, we're all for somebody's being perfectly healthy," then we have to ask: How does one get health, or get dignity—and these in part are from social institutions and not just—

STUART MUDD: We agree with that, but how do we present it in our document?

WADDINGTON: This is from what we discussed earlier—implementations and institutions—or are we just talking about population?

CALHOUN: We're talking about all four areas of the committee's mandate. In some ways these details involve strategies, implementations, and institutions. Some way, if we meet the challenge, we have to consider these issues along with the strategies and institutions and social issues.

SIMON: Or at least recognize their existence.

CALHOUN: Recognize and at least say that they're there.

SIMON: I think I get the message. One thing is that it's not a question of chemical or mechanical invention. Obviously, the failure of the birth-control movement and family planning throughout the world has had little to do with the efficiencies of one technology or another. It has a great deal to do with cultural resistance, and this must be acknowledged. There are, really, no simple solutions, none that don't anticipate this kind of problem. The fact is that we're fundamentally tampering with the culture, and it's in this sense immoral to go around blindly tampering with family structure in a critical way. Society is now very self-conscious of the responsibility of beginning to think about what's going to happen to its fundamental institutions and of offering people viable alternatives from which to select and resources from which to realize those alternatives. Is this part of it?

CALHOUN: That's it. How do people get cranked into the process of being part of the ethical decision making, which, after all, is affecting them as individuals? A lot of this is not under their own control, because it's the institutions that carry on these functions.

WADDINGTON: Are you asking us to draw up plans for institutions to bring people into decision making without changes in culture? I say, "So what?" as far as this body is concerned.

SIMON: It's really very much the same problem we had when we learned how to move into other societies and cleaned up their drinking water, reduced mortality rates, and then left them to handle the problem. We really thought that in this technocratic way we could solve fundamental problems. I think we're all getting a little nervous about the fact that this same kind of narrow, technocratic, biomedical commitment to family planning is being stated without the contextual linkages that say: There are all these other problems, and even if the programs were to be successful, the problems would be as great if not greater, unless the same people who were involved in these biomedical, technocratic solutions were prepared to think with equal creativity and equal commitment of resources about some of the sociocultural alternatives that have to be generated.

NG: The question to be asked now is: What strategies should we discuss at this point, and what mechanisms could we evolve at this stage, that would help to facilitate, or perhaps to make visible, some of the common problems that might be encountered in the process of trying to reach our final goal, which might be raising the standard of health, or any of a number of things?

CALHOUN: That's what I was trying to say: If we had an inventory—and I don't think we can do it today except to suggest, maybe, that there is such a thing. Perhaps there should be some sort of a rating scale, however; are social casualties, social cripples, genetic-deficiency cripples being dealt with; what are these measures of man? Can we have lists of this sort that we can some way qualitatively evaluate? Can we at least raise the problem and note that this is part of the strategy, at present, to increase awareness? Perhaps we could recommend the various areas of consideration for the nations. Then there has to be some framework with what's considered. For example, there are a large number of parameters; you can put down mathematical equations that are equivalent to increasing or decreasing population. If you disrupt social linkages, relationships in society break down if you increase population density, or if you have insufficient education to accommodate changes.

WADDINGTON: To some extent Ruth Sager's biological bill of rights provides a framework of values, and it seems from the biological end to have quite a bit about education and psychological development. As I understand it, you want us to recommend that nations set up institutions for considering the social consequences of birth-control techniques, and these consequences could be enormous if you change the sexual mores of nations.

MOORE: Let me see if I can try to pick up some of the threads. I think it reflects a difficulty with the first session's discussion about how we integrate the psychological and social factors, as well as simply approaching it from a physiological base. It seems to me that part of the problem is to emphasize more the psychological-cultural-social factors in implementing population policy and, secondly, the kinds of social responses and obligations you get: what happens to your obligations when you do this, when you undertake this kind of policy, in terms of side effects? I think, Dr. Calhoun, you have really suggested that there may be alternative ways of achieving the goals we started out with—the density issue, education, linkages that may be as critical in achieving population goals.

CALHOUN: I suggest placing a few examples at the end of agenda items for continuing consideration, to be sure there is an assessment from the biological point of view, from the medical point of view, from the point of view of social organization. There are different levels involved, individual dignity, education, health, and so forth, and they need to be considered and focused on. The question of the individual is the essential one, but we must back this up with what other efforts may seem appropriate, whether it's evaluating the total health delivery system in a country or what we mean by health delivery or environmental management. To mention institutions and to mention strategies is no way to begin recognizing which are appropriate and how well they're working.

WADDINGTON: On the purely biological side, it has always seemed to me that the expectation of life at birth is a pretty good summary index of the biological state of the population. Almost any physiological disadvantage in the population will affect the expectation of life at birth. I don't know

any similar overall index of social health of the population. If any social scientist can produce anything as meaningful as expectation of life at birth, it would be very valuable.

CALHOUN: I grant you that this is very simple, and, in fact, is easy to obtain, and it has wide implications; but this shouldn't blind us to the fact that there are other things that are more complex: all the synergistic relations are of that category, and they're difficult for even a scientist who is philosophically, intellectually oriented to grasp. If we don't grasp them we can't expect governments to grasp them or the general population to grasp them.

WADDINGTON: I started by saying this is purely on the physiological-biological level; the mean expectation of life at birth would be a fairly good index of physiological states. I don't know how you make any other single index that encompasses richness or harmony or whatever it is.

SIMON: There ain't none!

WADDINGTON: Well, possibly the mean expectation is going 'round the bend; some expectation of the probability of mental breakdown.

SIMON: This forces us to an endorsement of a kind of bland pastoralism, which I'm not about to endorse. The indices of mental-health risk also carry with them all kinds of things that strike me as being terribly desirable, as a matter of fact; for instance, the sheer complexity of life.

KEGAN: There is a corresponding idea that is much more limited but has been used a great deal, and that is mean income per capita, as a basis for judging. Mean income per capita is something that government policy can alter in the next year, or the next two years, in a much more immediate and direct way, and is so regarded by almost every government in the world.

CALHOUN: I was thinking, here, that we should list certain points, and that these would be such that they could be utilized by any individual or by institutions or governments to assay their present state of development; income is one about which we have been sort of brainwashed, if you will, into measuring the meaning of human life in terms of gross national product, or by our annual income, or by just length of life, and people sit around and vegetate after a while.

I would like to see that, in time—maybe it won't be right now—out of this will grow an inventory that individuals or institutions can utilize to assay where man is, or where he is as an individual, or the institutions that he relates to, how they are. The kind of thing, I think, should have some real meaning right now and not be as abstruse as the GNP. I personally have no concept of GNP.

KEGAN: I was thinking of incomes.

CALHOUN: Income still gets as abstruse as—

STUART MUDD: You are speaking of some range of index of the quality of life?

CALHOUN: But in such a way that it has some meaning for the individual person or the individual organization, and not as an overall index that has been fabricated and that you can't use except as a statistical or analytical process. We've got to relate to people and to governments so that they can build images; I think of Kenya, as an example: The people in Kenya should be able to have an image of where they're going. They may not be there now, but it's meaningful to them.

STUART MUDD: Is this your inventory?

CALHOUN: No, it's a beginning. This is Dr. Sager's biological bill of rights. This is a component, but we've got to go beyond this.

WADDINGTON: Can you go much beyond this without running into major cultural differences and social ideas? There may be societies that live contemplative, noninteractive types of lives, and there may be others that are much more interactive.

CALHOUN: I don't say we must get an accepted system; that's different. Even our items wouldn't be accepted across the board.

NG: Actually, we're talking at different levels. Dr. Sager's biological bill of rights is like a very beautiful symphony. In order for the symphony to be played we need to find out where the violins are, where the violas are. We have to determine what are the necessary components and the effort needed to make this symphony realizable and realistic.

Coming to the question, then, of strategy: how to assemble? How do we devote attention to implementation? There is quite a distance between step A and step B. There are intermediate steps that need to be taken. Then there are two levels of strategies; one is the general strategy; the other is the specific strategy. Sitting here and listening, we hear one proposal that falls into one specific category and another that falls into another specific category. Discussions of the GNP and things like that are specific strategies that I don't think, at this point, we are prepared to deal with, but we can mention them in broad categories.

The other question is a question of general strategies. We cannot, at this point, initiate ideas for a continuing body. We have to devise some mechanism that would provide a continuing dialogue, once we leave here, that would eventually be put into sustained action, so that we would have an interactive loop that might lead to the result—the attainment of what we might propose to do.

What are the problems? Obviously, one of the problems is to devise a plan that could provide some continuing activity after we leave this place. If we don't have the expertise here, a panel might be set up to find it anywhere in the world that could join in this effort, that could converge, perhaps, on some kind of common effort for the implementation of some of these bills of rights. I think we should, then, discuss strategies in terms of general and specific.

FRIEDHOFF: I think Ng and Calhoun are both saying that we have not only the right but the obligation to continue to try to solve some of these problems. If this is true of this body, isn't it really generally true that mankind, or the citizens of X nation, or whatever social community we're talking about, also have that responsibility? Therefore, perhaps, if we're going to address ourselves to this we need two introductory statements that are more general in nature, and one is the right to participate in making decisions that will significantly influence the quality of life of the environment, and two is the right to participate in the determination of the significant goals, values, and priorities of the society.

MOORE: I second what Dr. Ng said on focus, on a continuing agency; we should make some kind of recommendation to that effect. I would think that the appropriate forum would be a part of the World University. Let me just focus on a couple of things we might do. One would be a series of specific statements about things that we think *we* have the competence, at

whatever level of generality, to recommend and to release to the press; second, a proposal that a continuing agency of the World University be set up to consider a series of questions that we will develop in the areas of population, health, and family. Now, there are only three statements that would be appropriate to formulate. First, because we are approaching consensus on the question of population, we could release a fairly specific population statement.

Second: we haven't got back to the notion of an international study of the genetic and other low-level behavioral effects of toxic chemicals and other environmental pollutants. That's the kind of thing we could, perhaps, without recommending particular agencies, state that we need.

Third: I think Dr. Sager's bill of rights might be something that would be interesting to make a specific, concrete recommendation or endorsement of, and put it before the Conference.

The last proposition could be simply the recommendation of a structure for the continuation of our inquiry through the World University; this study would deal with such issues as the need for a broader approach to health-care delivery systems, the cost-benefit problems, the ethical issues, the need for paramedical services, how to provide the linkages for medical care in underdeveloped nations, and the need to focus on new institutions and procedures for dealing with the problems.

SIMON: Could I suggest an amendment on the question of environment control? We should take a very strong position for its real international significance. Because so much of it really depends on shared resources and interactional effects, it requires, also, international solutions and international controls. In effect, if you tell an emerging nation like India that its steel mills have to be terribly expensive, then this additional cost gets subsidized by everybody whose environment is shared.

WADDINGTON: We haven't got to environmental control at all, yet.

SIMON: The language of environmental control has been used, though. And it's clearly on this level that we have to push very strongly, internationally.

CANCRO: I don't know whether this particular point is too obvious to warrant mentioning, but I think it should be mentioned: the prime concern is the right of biological survival as a species. I think all of these other issues are, in a very real sense, subsidiary. We come, then, to the very difficult question of how does one measure or assess biological survival of the species in a way that scientists can agree on.

We *do* want to place this in some sort of context, and the context, as I view it, is biological survival, but we should be beyond that and say that once we have ensured biological survival, then we must ensure the quality of life, and this could logically feed into some of the social, political, and institutional issues that are tied together.

CALHOUN: The point that builds up is that survival is a steady-state sort of a thing, and you realize that there is not only survival but development without being open-ended; not knowing where this development goes is important.

SAGER: There is some disagreement in the discussion, because the spirit in which this was formulated by me was quite different from any of these additions, and I wouldn't agree with them as part of the original statement. That doesn't mean that this group can't formulate whatever they like,

but the bill of rights was written to look at the world from the point of view of the individual. Rather than calling it a bill of rights for mankind, maybe we should have said it is a biological bill of rights for the individual.

The attempt was made to bypass all comments or statements about social organizations, politics, or survival of the species, anything that could not be measured at the level of the individual. I think that the only recourse an individual has in an increasingly complex world is to measure the world against himself or herself, and that all the social schemes, in the end, can be evaluated only in the impact they have on each person. So in a sense this is a very revolutionary kind of statement. I visualized it that way because it makes enormous demands on social and political organizations; it doesn't say what is desirable or undesirable except in its impact on the individual.

CALHOUN: I don't think that it would be inappropriate for this group—and I'm speaking personally and not necessarily as chairman—in its report, to include this bill of rights were the report focused entirely this way, and were there not a transition to something broader. The suggestion made by Dr. Cancro was to provide a transition to broader issues that would ultimately give it, I think, much more meaning.

CANCRO: There is, of course, the right of the individual as a biological organism, and once having made the transition—

SIMON: Why is that different from the first two points that Dr. Sager has in her bill of rights? What do you have in mind when you say "biological survival?"

CANCRO: I would say that man does not live by bread alone, but it's been said before.

SIMON: What do you specifically have in mind other than shelter, clothing, survival against the elements? What are you talking about when you talk about biological survival? Some people mean things that make me a little nervous.

CANCRO: Like what?

SIMON: Some of the things we were talking about in terms of genetic engineering; eugenics. What do *you* have in mind?

CANCRO: I mean it as a way of getting into the broader issues. If you have a right to survive as an individual and the species has a right to survive as a species, then you must consider more than food and shelter, which brings us very quickly into social organizations.

WADDINGTON: It seems to me that the only point brought in by survival —the only point not already in Dr. Sager's bill of rights—is nuclear war. It might be taken for granted, but one could put it in first. But after that it seems to be that the right of mankind and the individual human being is to much more than survival; it is to development, which is what Dr. Sager has written. And I personally don't think we should go too far in expanding it, as our chairman has suggested, into politics; for example, that you have an individual right to participate in democracy, or something like that. I don't think that we should necessarily go that far.

HEDÉN: One thing that impressed me when Dr. Sager made the original presentation was her statement that these should be the rights of the newborn baby. This, to me, is fundamental, because what we are concerned with—many of us, particularly the politicians—are the voters, and I think putting the emphasis on the newborn baby is rather important, psychologically,

because it indicates the responsibility is outside the realm of immediate political considerations.

WADDINGTON: It's very difficult to mention the newborn baby and his rights, and also the teen-ager.

FRIEDHOFF: I think Dr. Hedén makes an important point, because if you divorce the content from the form it becomes essentially meaningless: every real estate developer in New York would say that he's providing shelter consonant with esthetic requirements, but not everybody would agree with him. If you do alter this and put it into context—this *is* a right of the newborn baby—I think that some of the necessity for talking about the forms is eliminated, and I would find that more acceptable.

MOORE: If we were going to approach this systematically from the broadest framework, what we are really talking about is working out a very detailed implementation for every value process, and that's not what we're purporting to do; it's simply a statement that's very strategically aimed at trying to influence national and international decision makers and members of the body politic, and although it's quite appropriate to do that, there's no need to put everything into it, such as the politics of participation in the decision-making process.

I would add that I was somewhat shocked that in this august gathering of medical people there was no statement of the right to the highest attainable standard of medical care. This seems to be an individual right that ought to be included in a biological bill of rights. There were a couple of other minor points, also; the right—

WADDINGTON: The right to stay alive under various conditions—how are you defining medical care?

MOORE: We had that same problem with every other issue, here.

EMILY MUDD: A healthy total development.

CANCRO: Dr. Sager wrote "physiologically healthful environment," and that's about as broad as you can be.

HOTCHKISS: To make it "medical" is again mentioning the apparatus.

CANCRO: It's such a small part of the whole business of survival. And then you'd get into the argument of the right to technical services, and—

STUART MUDD: As a medical person I'm a little afraid you will get into Pandora's Box.

EMILY MUDD: Healthy development includes both emotional and physiological.

STUART MUDD: I'd stress one point that Dr. Moore brought out, and that is that the framers of this Conference organized it with the idea that there would grow out of it four or five commissions to carry on the work, so that what we do here would not be done once and forgotten.

EMILY MUDD: But it should say something that would grip people enough to make it worth while to carry on.

CALHOUN: I think that our intent is to give Dr. Moore the privilege—which he already has as rapporteur—the sanction of the group to consider the essence of this bill of rights, on which we can't reach any final agreement in terms of complete wording—

MOORE: I would like the guidance of the group on what we ought to do on this. Although I'm in the position of drafting the statement, I don't want to interject my own personality. I feel that I have enough guidance on the population study and that it's the feeling of the group that we ought to go ahead and present it to the Conference as something the group endorses. I would like to see us, perhaps, simply present to the Conference the biological bill of rights for individual man, as not necessarily endorsed in all its details by this group but as something we present for them to consider.

HEDÉN: I would suggest that—since the points raised by Dr. Sager were part of a long paper wherein these points were elaborated, and it's obvious that she has done a lot of thinking on the specific points—it would be natural to suggest that we ask her to help the rapporteur in the refashioning of some of the points.

HOTCHKISS: I wanted somewhere to make one suggestion, if not on genetic engineering, then on the gene pool as a public matter, being the aggregate of individual genomes. As I was thinking of a preamble to this statement I found that it was fitting in more and more with a reaction to Ruth's bill of rights, and to what has been said about the interrelations.

So I'd say something like this:

"As we consider the individual in his society and his world, the difficult and desirable goal is to retain maximum concern for individual liberties, initiatives, and expectations, while moving toward collective planning, decision, or regulation.

"As such, the concerns become the legitimate subject for social, legal, and political action. In this manner, the aggregate of physician-patient relations becomes the subject of public health, and individual hygiene becomes cumulatively the topic of preventive medicine."

I worked these in because we seemed to be talking about them. And I wonder, would it be a good transition, after we state an individualistic bill of rights, to talk about how this is translated into social and political action? "It is worthy of increasing attention," I was going to say, "of the gene pool of mankind, a concept quantitatively and qualitatively defined by geneticists," something like that, "may soon become a legitimate subject for social control." This is as far as I got.

FRIEDHOFF: I don't have much to add to what you said. I think it's consonant with what I was trying to say before. The only issue that I would like to re-emphasize is that the highest priority must be given to the issue of deciding priorities and values and goals in our society, and very little attention has been given to this issue itself. I think your statement is beginning to emphasize that these kinds of issues must have high priority at all levels of social consideration and that in this way some of these objectives can be spelled out.

CALHOUN: I wonder if the rapporteur could take that up. The issues are, if I interpret them correctly, that individual rights have ramifications in broad social problems, and at this level the concern is with developing of metapriority decision mechanisms concerning how we go about deciding on what our priorities are—this is the highest priority—and obtaining the maximum involvement of people in this process, to be sure we don't lose track of the individual.

WADDINGTON: I'm getting very apprehensive about this. You are saying there are social values that may override individual values, or you're getting very close to saying that. Now, society undoubtedly is involved in implementing these individual values that were given as goals. They can be achieved only by social action and education. But this is serving, still, the needs of the individual. If you start saying, "Now there are social wants

that need looking after in a different way," you come close to—or you can come close to—Hitlerism, to totalitarianism.

CALHOUN: That wasn't the statement. That wasn't what he was saying.

FRIEDHOFF: I think this is one thing that concerns me about the initial wording of Dr. Hotchkiss' statement. In fact, I think, at any rate, that I'm saying just the opposite, that there are individual values that override social issues, social matters, and that these individual matters have to be considered as the highest priority, but that they can be considered or given adequate attention only if we *do* have some notion of what the priorities or the choices are in the society.

CANCRO: I think we're having one of the classical problems of dichotomizing and saying either "social" or "individual," and somehow we have confused them.

HOLLAENDER: I would like to see a very general statement—good food, good clothing, and freedom, and all that. We still need a little more; how to bring it in I don't really know. We don't want to go into specifics; if we do, the whole thing will become very confused.

MOORE: I also have the feeling that something is missing. We sense a desire to jump from problem identification and the formulation of goals to the question of the whole structure of society in the institutions of decision making. I think that should be in our statement, because I think it's important. I would close with some of the issues for continuing appraisal, we recommend that there be such institutions established, and that there be concern for how decisions can take in all of the areas we are discussing and the kind of participation in decision.

I wonder if we can really do that. Can you get specific on that issue? The individual versus the social is what the law deals with every day. There *is* no dichotomy; all social rights are individual rights. It really comes down to a question of different, competing interests that we're trying to mediate. So I don't quite know what we can do or where we're getting to.

FRIEDHOFF: I think, again, that I don't believe we're in a position to recommend the form or forms that this would take, but simply that some consideration be given to the evolution of forms for use in these kinds of decisions.

WADDINGTON: I think the statement that Dr. Hotchkiss brought in on the human gene pool—this is something of social value, but the individual participates in it only as a potential donor. His genes are his own. When you talk about genes he thinks about what happens in the next generation, not to him, whereas these other independent social values hinge on the existing individuals. So I don't think it's a good idea to try to use the gene pool as a mode of transition from the individual to the social area.

HOTCHKISS: I had in mind a sentence such as "The individual chemical and physical insults to the atmosphere and hydrosphere become the problem of pollution," for example. But we're going to take an awful lot of time if we try to make specific recommendations.

WADDINGTON: Is it not adequately covered if we state these individual rights and then point out that the implementations of any of those rights can be carried out only through social action; I would say that there should be a continuing commission and a continuing consideration of the modes of social action or social organization, or both, to implement these individual rights. Nothing can be done by an individual for himself.

FRIEDHOFF: I move that we adopt those two recommendations as an amendment to the statement.

CALHOUN: I think we've come as close as we will come to providing a framework for Dr. Moore to communicate the sense of the group.

SIMON: I think there is a tendency, in groups like this, to move toward agreement and clarification, and thinking that ambiguity is merely a reflection of our own sloppy thinking, and the fact is that life itself is frequently ambiguous. We have skirted the whole issue, really, of social values versus individual values. Camus devoted an entire volume to this in "The Rebel," and, for him, although the concept was that the aims of justice were the aims of freedom, he ultimately concluded that they were basically incompatible and that a creative man as well as a creative society learns to live in the tension between the two of them. If anybody is going to try to get the language down, I hope that the ambiguities that suggest the complexities of life will show clearly and that it will not be because we haven't finished our thinking, because that's one of our intellectual responsibilities. Furthermore, we need not only set goals but also make people aware of the kind of complications and difficulties there are in realizing those goals. They're not as simple as we tend to make them sound. Somehow, I'd like to have this set down so that the conflicts and ambiguities are out there, in the real world.

WADDINGTON: May I pick up one point? There is in Dr. Sager's statement something that is very important and, I think, to be emphasized. She speaks of diversity, and this is the only mention of the real complexity of social life, and I think this is characterized by human dignity and a full acknowledgment of the essential human diversity.

SIMON: Some work that isn't creative has to be done. Some people have to make a sacrifice in some part of their lives. It's naïve to try to create a kind of psychological utopia. If we want to be taken seriously, we have to admit some of the problems and some of the realities; some of the confusion is *not* ours; it's the world's.

CANCRO: It's like a cross-benefit situation, a trade-off, if you like. There has got to be a trade-off between individual freedom and society's needs.

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HEDÉN: We will try this morning to cover those things on which Dr. Moore needs specific amplification for our statement. One thing that Dr. Moore felt was lacking in terms of areas and directions we want to cover is the family, family structure, and what types of family we want to see in the future. Also, when we discussed health problems, Dr. Bjorksten was not with us, so it would be good if perhaps he could begin by discussing his point of view on aging, with the particular emphasis on implications for the family. We all know about the family structure in the old days, when the older people were strongly involved in taking care of the young.

BJORKSTEN: The problem of aging is one of extreme importance in health, because all the major diseases are interdependent. While total life expectancy has increased remarkably, because of improvements in reducing infant mortality, there has been almost no increase in longevity after the age of 60. A person at 60 today has only a 1.1-year greater life expectancy than he had in 1789. So it seems that in changing the course of pertinent research we will have to be patient in order to overcome this difficulty.

On another point I would like to draw an analogy: suppose that in the

year 1540 a conference was called and given the task of finding a better way of lighting the streets, something to replace the old-fashioned candles; suppose this committee had in 1540 said, "Now, let's take the million dollars that the Government gives us for this, and spend that money on making better candles and better torches, and maybe some kind of culture to get better whales and better whale oil." If they had proceeded in that fashion they might have increased the efficiency of candles by some factor, but I don't think much difference would have been made. On the other hand, if the committee had said, "We have reached the point of diminishing return; we have reached the point where we've got to take another step," maybe some courageous soul would have said, "Lightning is the greatest power there is, aside from the sun: let's look at what makes lightning work." If that approach had been taken at that time, the whole science of electricity might have been advanced by many years, and we might then have been that much ahead of where we are now.

We are in an analogous position now in relation to health research. We are in the position of diminishing return so far as health and longevity after the age of 60 is concerned. I submit that one of the principal things this Conference could do would be to say, "Now here is a point that deserves attention and from which a departure is of the essence if we are to get the maximum benefit from our research and from all our efforts on disease, because they are all interdependent." In other words, one of the most constructive things that this Conference could do would be to adopt a resolution stating that a switch of a substantial part of the research budget is in order. The major medical research emphasis should be switched from attention to individual diseases to the task of clarifying the basic mechanism of aging and the means for controlling the aging process.

HEDÉN: I think this is very important, and my only hesitation is that it constitutes a relabeling of things that are now being done. I'm thinking, for instance, of the processes in immunology; the effect of aging on the immune system is something that is actively being pursued. There is, of course, a lot of activity in gerontology; there is activity in physiology; certainly a lot of pathology is concerning itself with aging. The advantage here is essentially one of the psychological effect, in the sense that one achieves the same thing as one has done in focusing on cancer, where one provides a landmark—a flag—that can be waved around so that one can attract public opinion and get support. This is, in itself, of course, a very important point. But I wonder, as far as the actual research operation goes, whether there would be any profound changes in the actual avenues of approach taken.

BJORKSTEN: The major part of the work that's labeled pathology is descriptive, it is descriptive of and deals with palliative measures, and it is directed to degenerative diseases, to situations where the process has already advanced very far, so that we're no longer dealing with primary effects but with secondary effects. The sums spent in dealing with the origin and basis of aging are very, very small indeed, at least in this country, in relation to what we spend on certain specific diseases.

WADDINGTON: I'm afraid that if we started to lay down principles for medical research, we would be really pre-empting the functions of bodies at least as eminent as ourselves whose job it is to direct medical research. I know that the British Medical Research Council has before it several projects for research on aging, with a number of different hypotheses about aging. I'm not prepared to say that there are enough of these projects, but I'm also not prepared to say that there are not enough of them, because I'm not in the business of assessing them. There are research councils—at least in Britain—whose job is to assess the projects coming before them in order to see how much money should be spent. I don't think that we are competent to make a snap judgment that there isn't enough spent on aging. You can spend only in the light of the suggestions that come forward. Aging is obviously an extremely important problem, and it's very true that there should be increased understanding of it, but I think one could find other problems that are also important. I simply don't think it's our function to tell the research councils how to do their business.

CANCRO: I would agree with that, but, in addition, I think that the general spirit of what we've been talking about has been to emphasize that a high priority has to go to the interaction of environment and biological factors, but this does not at all take into consideration the tremendous problems that would occur with any significant extension in the length of life. If we were to pass any resolution about aging, it should be one recommending that consideration be given to problems for society raised by an extension of life.

HOTCHKISS: My impression is that we're giving testimony to our feeling that biologists collectively will tend to create their own rallying point, that the flags of medicine tend to wave spontaneously when a certain body of information collects that's adequate to give it an identity. I think perhaps the consideration should be the relation between the scientist and the community or the response of the social agency.

CANCRO: I'd like to make a point that may sound more critical than I intend, so let me apologize for it before I say it. The idea of extending life in a variety of ways and slowing down the aging process during life to provide richer experience in a variety of ways is certainly to be lauded. But in my personal list of priorities I would be more concerned with affecting the quality of life as it exists now before upping the ante and saying, "We'll have more of the same or more of less." I would like the same amount of better—and then we can worry about the time span.

HEDÉN: We have to define what we mean by aging. As I understand it, the process of aging starts at 17 years of age.

CANCRO: I wanted to make clear in my remarks that this is something that goes on throughout life, and I'm not in any way trying to deprecate its importance.

HEDÉN: Maybe we should talk about degenerative phenomena in order to remove this element.

BJORKSTEN: I'm going to talk now to the problem of interaction, which is a timely one. But before doing that I would just mention that when it's a question of whether to change course or not, it is also whether the people who have been making the assignments should be trusted further or not.

A little remark on the question of interaction: We are all assuming that the present course of development of humanity will be a useful one, and that the only thing we have to worry about, or the main thing, is population increase, and that the increase in enlightenment and prevention will be brought forward. That is a result certainly to be desired, and I hope that will be the course that events will take. But we cannot wholly disregard the other possibility, that the population will not be controlled, that birth rates will mount to an intolerable point, and that the result will be some counteraction by nature or man that will lead to a dramatic destruction of large segments of humanity—maybe an atomic

war, maybe another kind of pestilence, maybe an extremely widespread famine. Those things are all possibilities, and maybe some of them are a little greater possibilities today than they were yesterday.

If something of that sort could happen, it could turn out to be extremely important, from the point of view of interaction of states for the survival of humanity, to have the means of increasing the overall reproductive lifespan dramatically. Should we refrain from research along those lines merely because we have such extremely strong hopes that the other effect will be the one to prevail? I submit that this is something that still deserves thought.

ERAJ: When we talk, it is often in the context of developed countries and developed people that are very much more advanced. The situation in Africa is such that at the age of 50 a man is already old. He acts old, he thinks old, and he's called old. The emphasis that Dr. Bjorksten has given is very useful. Certainly, in my part of the world, a woman of 40 thinks she's old; she's finished, and society accepts this as a fact. It would be a great contribution if more emphasis could be given to the aging process. I know that some research is going on, and perhaps there truly is nothing new under the sun. But we are not going beyond our means if we lay stress on this particular point.

SIMON: I would like to see a much greater concern for the process of aging. Aging is not only a physiological process; it happens to bring a change of social roles, and I think the problem in the Western world and also in the underdeveloped world is the problem of having to invent a role; this is a concept that I think becomes increasingly critical, in addition to the degenerative process itself. I think it's quite absurd, at least in the American experience, that aging is really a process of disengagement. It's a social and psychological thing that ultimately has consequences for health and mortality, the kinds of roles people play—people, incidentally, in whom society has invested a great deal. Look around this room. I think it would be a rare graduate school that could show the energy and creativity of the senior members of the intellectual establishment, in so many ways. I think we should now begin to elaborate this in terms of psychological and social contexts. Gina Blau's research, for example, begins to suggest that aging and health really are very much dependent on self-conception, which depends, in turn, on what your reference group is. If you are with young people and doing things with them, you remain healthier and you conceive of yourself as being younger. If your reference group is such that you begin to be more aware of diseases of older people, then you tend to have mortality expectations similar to theirs despite the fact that you may be somewhat younger.

CALHOUN: I think Dr. Simon's idea is that there is a real point of union regarding aging and that this is not just a physiological process. It might be that using aging as a focal point might be good if we talk about the adaptation of systems for continuing life; whether it's social systems in the life of the individual and his social sphere or physiology, we examine the situation in terms of what opens up and gives freedom to the processes of the system and the individuals.

This is a salient and general point in which the physiological aspects—part of the adjustment is that we're looking at pollution and at population in the context in which, by analogy, we're looking at cancer or renal disease. We need to look at the basic processes of adjustment to change and evolution, which is the process of keeping the system sound.

WADDINGTON: It seems to me the topic has now been considerably broadened and deepened. When we started, we were talking about expectation of life at the age of 60. We're now talking about the richness of the whole progression through life history. We're now talking about aging not as simply a degenerative process at the end of the normal life span but as related to the rate of progression and the rate of decay throughout the life span. That is obviously a major part of what we have previously termed the quality of life. The quality of life, roughly speaking, might be divided into the rate of decay plus the richness of experience throughout. Another factor in the quality of life is the number of different types of interest and different types of connections and different types of communications and relations that one has.

I think, therefore, that the way Dr. Simon and some others think of aging makes it into one of the major aspects of the total quality of life. There I think we're on quite different ground. Indeed, this comes into Ruth Sager's declaration of rights.

HOTCHKISS: There remains a point that might be worth consideration. Evolution, we could say, roughly, was selected to produce as many progeny as possible, and at the time that we cease being reproductive we cease being under directives from evolution; we have, presumably, only secondary roles, such as the tendency to right social systems; the tendency to care for—

WADDINGTON: Man is a cultural as well as a biological animal.

HOTCHKISS: In this way we could be interested in the growing man. We have a suggestion before us, and what I object to mostly is the idea that we should remove the emphasis from other things and recommend that they be transferred. I would not like such a statement.

HEDÉN: But this type of research is essentially one that might involve people outside the medical field, and we want very much to see that this is a research topic involving a lot of Ph.D.s and mathematicians, and so on.

CANCRO: Both Dr. Simon and Dr. Calhoun very nicely brought back the quality issue I am concerned about, and there's surprising unanimity among the group on this point. I'd like to make one or more very minor, but I think very practical, suggestions. You can get a fact, such as that in the last 101 years life expectancy for a man of 60 has risen only 1.1 years; this creates a certain emphasis that vitiates any kind of interdisciplinary trends. I think we have to be careful in utilizing that kind of data in any statement we make. Another thing: It might be very useful in such a statement to redefine aging, because aging has certain connotations, especially in the minds of the non-scientific community. If this sort of material would go to the political body of the United Nations, and they see "aging," they're not going to understand it in the sense that we're trying to define it. It would be very useful to say that the traditional definition is too limited, too death-oriented, and then to bring in a definition that emphasizes more development from the beginning, through the middle, through the end, across biological, cultural, psychological parameters.

HEDÉN: That is a good point, and I think Dr. Waddington gave an excellent definition when he said that it was a question of rate of decay and richness of experience. Isn't this a pretty comprehensive sort of statement?

CALHOUN: I feel good for the first time in these sessions. We are coming into focus, and I'd like to bring it even more into focus with a remark Dr. Hotchkiss made, when he said that evolution has to do with increasing reproduction, with more progeny. The question here in uniting the biological and the cultural is the question of what's being reproduced, and this was partly put in focus with Dr. Waddington's remarks on the reduction in the rate of decay and

the increase in richness of experience, with connections between experiences, which in the end means the reproduction of ideas.

And so we're shifting from biological reproduction and evolution to ideational reproduction, which is really the focus of man, *and* the necessity for a longer physiological life. This was pointed out in a lecture on Methuselah four years ago: Why produce longer physiological life, since it is not necessary to have a longer reproductive life? It is the essence of human evolution itself to increase the opportunities for the individual to become programmed so that he can make a greater contribution in ideas about relationships and richness of experience. If, in that context, we add physiological aging and give the reasons why (because prolonging life will have many consequences), I think perhaps we'll get to a point where we could have a focus that does help unite various factors.

MOORE: I am in complete agreement with Dr. Simon and with others about the terrific importance of focusing on the policy implications of the extension of life, and the interaction between the social-psychic side of man as well as the physiological; I wonder, however, how decisions like this ought to be made, what groups of society ought to make the decisions, what kinds of input should they have, and where do they come from?

Suppose you really were faced with a scarcity of resources, which I suppose may be accurate, and scarce resources of medical research, how do you go about deciding the cost-benefit ratios, and to what extent does the man in the street have a concern or some kind of ability to participate in that process or to have his views represented? I'm not intending to write participatory democracy laws on all these issues; I'm just raising the question in a philosophical sense about how one decides this kind of issue.

HEDÉN: Do you suggest that the old people would be oriented toward research in aging and young people would not? I think that would be a deeply unrealistic view; certainly the research being done now does not have an impact on those who are old now. If we make an effort and if this research is successful, it would have an impact on those who are young now—

CANCRO: There are emotional priorities as well as practical ones.

UNIDENTIFIED DISCUSSANT: I hope that you will emphasize words that will imply the quality of life and vigor and enjoyment and all these things, rather than aging. I think aging lends itself in the public mind to a very narrow and terminal sort of interpretation. As a doctor, I have been brought up to conceive of aging as progressing rapidly from birth on, with the rate of aging greatest in infancy and gradually slowing down. Autopsies on young men killed in the Korean War show that they all had arteriosclerotic lesions. Aging lends itself to very much misunderstanding.

SIMON: Because we are really dealing with a sociocultural process as well as a physiological process, there is danger in trying to extrapolate from the past to projections for the future, because you may be using images to determine future policy that really represent the past while none of those processes are involved.

Let me mention two dimensions of this. Aging for men means the end of work, and the end of work means a sense of futility. With women, the major sense of self depended on family role, and when that was gone there came this interaction that tends to react very powerfully on the physiological processes. But, at least in the industrial nations, the whole youth phenomenon seems to be driving us up the wall. For the first time in urban industrial societies, there

are people who are trained to conceive of themselves as doing many different things, and in terms of projecting this into the future, the problems of integrating these may be something vastly different.

I want to interject a cautionary note about not letting a rapidly changing world and the social images of the present, which are all too often reflected predominantly from the past, color our sense of what we really can do, and what kind of redesign is possible.

WADDINGTON: I want to draw attention to the importance—if not in all the world, at least in advanced industrial societies—of premature aging; it occurs not only in Africa, it occurs among Italian peasants; you can see it in Europe quite easily, and it really comes primarily from overextended manual labor and unpleasant conditions, and this is still a very important thing in the world. Any formulation about the quality of aging is in relation to the quality of life.

HEDÉN: This ties in, in a sense, with the question of the economic toxicity effect and the effects of different sorts with the chance of toxicity in the environment. Our rapporteur has expressed concern that we were perhaps unclear as to what we thought the priorities were, but I doubt whether we're going to have time to really go into the problem in any great depth.

Dr. Mudd, what is your feeling with regard to the impact of the aged on family structure? It has been said, of course, that the family structure during the days when the old people participated in taking care of young children was extremely useful from a sociological point of view. Do you have any comments on the question of family size and family structure?

EMILY MUDD: In terms of the kind of environmental process, I think it's very different in developing countries; it is also different here between the rural and the urban communities because, just in terms of size of dwelling, there is not room; nor can most young people, even if they wanted to, afford an apartment big enough to have a grandmother who might be a great help with the children and who is very lonely and isolated. We have an environmental problem in terms of the cost of living, which precludes much of the interchange between generations. Many young people feel very sad about this. You find a different situation in the rural areas, where there is more room.

Related to this, I would like to comment on the medical responsibilities that now are assumed of continuing life, even when the individual doesn't want it; there are many homes, for instance, in this country, where people who are completely senile are kept alive by medical processes at tremendous expense and at tremendous hardship to their families, and it is claimed as a responsibility. I think there is in England now a Society for Euthanasia; anything of this kind is a priority, and many of these old people really do not want to be kept alive and are just helpless, and it's a tremendous strain financially on the whole of society.

SIMON: I also want to go on record as being in favor of man's right to be free from hopeless and meaningless pain. On the other hand, I'm against the broader application of this notion as a kind of cop-out; it's a bad economic idea that you can't design effective social solutions for these things. I think we should distinguish between social decay and extreme physical decay, and I am unequivocally for sparing people that kind of pain. There is a notion of uselessness and futility of existence and joylessness of existence that characterizes so many of the settlements for the old. I think we can handle this by social design, and it's important to do so, not only for the sake of the aged people, but because all humanity is involved. The whole human quality of

society should be reflected and amplified by the ability to respond creatively to that kind of problem. The young should be made to understand this as a problem and feel that they're partly responsible for it.

CALHOUN: Following this line of thinking raises the question of what the family is. Erikson, in discussions with Julian Huxley, indicated that the basic drive was for general fertility; but there were levels, and it was something that had to do with family: the first is biological generativity; that's the primitive level. The second level is the generativity that's involved in the transfer of values and information to the next generation; the third is the generativity of the creation of new ideas. These can all be considered as functions of the family. Our own research has led to a fourth, and this is the fact that whatever the family is, the extended family, it has to provide the rate and quality of the kind of contact that produces the most gratification of social interaction.

If we take these four criteria as defining the family, we could not add what may it be now; it is what may the family be in a changing society to fulfill these four functions? And we must not get hung up on maintaining the historical family, which is now quite irrelevant.

CANCRO: I'd like to present the idea of the role of space in these splits between generations. I think an enormously important factor contributes to this isolation as a value system; a value system that emphasizes privacy, by which it means growing up, which means being by yourself, which means separation from the older generation. As opposed to psychological separation, it means geographical separation.

I have seen any number of cases where people could well afford and in fact could use having their widowed mother around, who would be a great help around the house; they have plenty of money for her and plenty of space but don't have the money for a live-in maid and they'd love to have her; the idea of that other person in the house, however, is too much, and I think this leads directly to a question we might want to look at, even though perhaps this is more physiological or biological, and this is the problem of values. How do we influence values? How assess them? How alter them? Not that values haven't changed drastically in the last few years, but I would be hard-pressed to say how this change came about. If you said you wanted to move in a particular direction, I would be even more hard-pressed to say what to do, and I think we should give some thought to this problem.

WADDINGTON: I wonder how far we can really go into this in view of the fact that there are other working groups, one of which has as cochairman Margaret Mead, who has recently published a book on this topic?

CANCRO: Aren't they on education and communication?

WADDINGTON: I suppose they would be talking about those things. Dr. Mead has laid such stress on the question of whether you are in a culture in which you expect to be brought up partly by your grandmother, in a culture in which you don't expect to be brought up by anyone beside your mother, or in one in which even your mother doesn't enter in.

HEDÉN: This presupposes that the parents or the grandparents are competent to convey the information. But there are cultures where we don't think the parents are competent. Can one approach this by sociologic criteria, in a sense? Are we failing in the sense that we are not giving the older generation the type of information that could usefully be transferred to the younger generation?

WADDINGTON: I think it would be more appropriate to consider the impact

on family structure of the changing age distribution; we're going to have a much more broadly based pyramid, with many more young people; then, if we succeed in mastering the population explosion and cut down the birth rate, we're going to have a large number of young people in the reproductive area, but a relatively smaller number of children.

EMILY MUDD: I have contacts who simply don't think of the family in the terms that we're discussing it at all. They think of it not in economic terms or in terms of institutions, but in terms of how they feel about each other; marriage may or may not be what they consider, nor even possibly producing a child and taking the consequences. In Washington, I know of six group-living situations, where the parents may or may not go out and work for part of the time and in which there are children, and the children are cared for by the men, if they remain. There are differences in identity in Erikson's terms, and it becomes a very confused kind of problem.

HEDÉN: Do you expect that this type of group relation will be more and more prevalent in the future? Will the traditional systems decay?

EMILY MUDD: I don't know. I think some of the materialistic values so prevalent in our culture are now being questioned by the young. They don't care if they have Venetian blinds, or this, or that. They have an entirely different concept—of a much simpler life, somewhat between that of the hippie who has gone off into the mountains of California and that of the young person who is living in a very simple way and has no materialistic ambition.

SIMON: This fascinated me, having lived in such a group—and they were some of the happiest moments of my life, as a matter of fact. But I want to go back to what Dr. Waddington was saying. I think it's important that we establish the legitimacy of our claims to move into these various psychocultural realms as they affect problems created by what biology and science are doing and, indeed, as they begin to change the conditions and responsibilities of our times. One example comes to mind very quickly, and it concerns population control. The assumption is that to have a stable population one ought to have two children per family. Obviously, however, there are large numbers in society who have more than one family.

I think it has been said by someone that the responsibility of the anthropologist is to find a way of codifying kinship systems and the job of the contemporary examiner is to find ways of codifying ex-kinship systems—whose kids are in what house on what weekend? Obviously, the very meaning of possession of families is a critical factor, and if it's not a new way, it's a highly intensified way of viewing what we had before; very few people in family planning have talked about this. You have your two children spread over how many marriages? What does that mean in terms of establishing binding relationships?

KEGAN: Well, there's one measure that's coming into prominence more and more in the developing countries, and that is that there are other consequences to controlling the size of the family, and that is social security. This does two things at once in changing values. It means that you no longer are dependent on children, that the older people are free; this also, of course, helps in reducing the need to have more children in a family. It seems to me that the trend is toward the more effective and universal introduction of this kind of measure.

WADDINGTON: Going back to Dr. Simon's point: if you're going to have only two offspring per two adults, and the adults in their lifetime are going to have six or seven partners, there aren't enough children to go 'round for each

pair to have one. People have a belief in "This is my child." One of the things one might consider is how social scientists can reduce the feeling that "this is my child, and that one's only adopted," or "that one has a different father." This is also related to the possibility of utilizing sperm banks, whereby the child is definitely the child of the mother but not the child of the father. It might be argued that man has largely, on materialistic, financial grounds in the materialistic West, come to lay much too great stress on actual physical paternity or maternity. The relation between a father and his child is largely dictated by chance and has very little, actually, to do with the character of the father.

HEDÉN: But if you give up this sort of emphasis, won't you also give up the element of responsibility? You have to think in terms of transfer of responsibility from the individual to society.

WADDINGTON: You don't give up responsibility for adopted children, and people adopt children now, usually, when they can't have them themselves.

HOTCHKISS: We might liberate ourselves and simplify our problem a little by taking a view such as this: We belong to various allegiance groups, and if we're threatened by a spaceship from Mars, or if we feel threatened with humanity, or if something happens between nations and continents, we withdraw our allegiance to that continental group; and as we go through these successions of local allegiance to tribe, the real thing is that we would have a profile of all allegiances; maybe if we'd try to see it that way it would simplify things for us.

HEDÉN: Maybe it would simplify the issue or condense it, but it would also widen it enormously.

CANCRO: Recently I did a draft paper in which I tried to look at the family from the point of view of the effects of technological change. The basic thing is that the family is a social unit that has evolved historically as a means of maintaining the species, and it evolved in a way consistent with the functions it was supposed to serve in terms of the species. On top of this was grafted the psychological values of the intimate relationships and the dependencies that today we see more in psychological terms.

Many of the problems of species survival—food, transmission of the culture, and so on—have been solved by technology or have been delegated to such other social institutions as church, school, medical services, so that many of the traditional values of the family as a biological survival mechanism are no longer relevant. If we look at it from this point of view we ask ourselves: What does the family do? What is it likely to perform? What has it done that can be taken over by other units, or how can the units be redesigned? A child-rearing function has to be carried on by institutions in the society; it need not be the family. We might be able to develop professional child-rearing people, and the biological parents will have very little input into rearing and development.

The psychological needs that people have can be satisfied, to a great extent, in interpersonal adult relationships. Then the whole pattern of the family becomes one that has to be set aside, in a sense, and redesigned. Basically, what I'm trying to get across is this: If we look at the family and say, "How can or will it be altered?" we're working on the assumption that it must continue. We are saying, "How can we take the university and reshape it to meet these new problems?", instead of saying, "Maybe it's the wrong garment for that job. Let's look at the goals; let's look at the purposes, and then let's see if the family can be reshaped—and if not, let's see if we can design something else.

HEDÉN: I think this sort of technological approach is interesting, but I think also that it may be important at this stage to ask for some psychological considerations. What is the current thinking about early exposure of the child to a specific individual? If you have "group relations," would you have institutional care of the very young child? I think that the very young child would be exposed to all sorts of things that would show up later in behavior as a result of that exposure.

CANCRO: One investigator with whom I discussed this recently (and he is as good on this area as anybody around) contends that the traditional point of view of a different face every shift with which the kid can't cope is wrong. This follows when you have one nurse and 40 kids and she neglects all of them. Control studies have been done with one nurse and five women per week—but they assign only three or four kids, and the kids do beautifully. In fact, they're suggesting that these kids are evolving better than they expected, and better than controls who live at home.

HEDÉN: From what point of view?

CANCRO: Greater development: psychological—

HEDÉN: Certainly, I could visualize that the amount of creativity that could come out of it might be greater, and a lot of other things, but what about security?

CANCRO: All the measurements show that the kids are doing as well or better.

SIMON: I'm not sure there is a fundamental necessity to have security. The only thing is, instead of having one godlike figure, you have more than one, and this brings us to that word that Freud made so powerful: ambivalence. Indeed, we now know that we have the ability to have numbers of people around with whom you are intimate; you can see them more realistically because you don't have any one exclusive object. This is the thing that is so beautiful about the idea of the communal family. The one I was in had about nine adults and only one child. It was in Berkeley Hills, last summer, and, in terms of our talks here, we weren't overly concerned about biology and genetics. We conceived of the family in terms of its reproductive role. I should like us to view the family as a place where one could have rich results even at the expense of the children. In this group, one day, a child was acting up, and one of the women—not the child's mother—simply reached over and bit him on the behind. It was beautifully effective.

EMILY MUDD: I was thinking that there are published studies about the *kibbutzim*, where the children spend about an hour and a half out of the day with their parents; the rest of the time they are in group situations with, presumably, a loving, caring kind of teacher. But the real question is, what kind of security are we talking about? The security to face the world of change with independence and not being overly tied up with any one identifying adult. I think our whole concept goes back to the family structure and that the child develops security from the love of the mother. Is the world of the future going to enable the child who has been brought up in this protective environment to cope in a very raw and cruel kind of situation? Look at what we're doing to our young—sending them out to Vietnam. Does our nurturing life prepare them to handle what we ask them to do at 18 years? I think there are many questions

of values, and we're so tired of thinking in Freudian terms, really, that it's very hard to get out into a different context.

WAKEFIELD: It seemed to me that what we talked about earlier—the process of adjustment to change and the richness of experience—has great significance for the family; I think we're validating that now by saying we should pay the same attention to these concepts of adjustment to change and to how we can identify richness of experience applied to the whole field of population health, and particularly the family. So let's look at what we do with this institution. I think if we emphasized this process and the need to look at the evolution of these institutions and human relationships—that's where we'll do the most good.

WADDINGTON: I think a great many studies have been made, particularly by anthropologists, on different types of family structure, and a lot of what you're talking about in the communities and *kibbutzim* and so on, Margaret Mead has documented very closely in her studies of the Balinese, among whom there may be five or six women at least who will pick up the baby and hold it to their breast. There is a great range of quite intimate contact with several women and several people of the grandmothers' age, also. There are Mohammedan families or Chinese families with several wives, where again the children are in a much wider community of people. It has always seemed to me that this should give a child more sense of security; it should give the sense that if your mother happens to be cross and has a tummy-ache, you can go to somebody else who hasn't got a tummy-ache and who'll be nice to you.

SIMON: This puts relativism as the medium for social approaches. This could be very dangerous, because of what has to occur now in a complex, urban, industrial society, in an unnatural environment—

WADDINGTON: What I was going to say was that we are now in a situation where we are limiting the family to the two parents and their immediate children. We're cutting down the family from what it was in our grandparents' generation, when there were a great many more adults. There were parents, and grandparents, and uncles and widowed aunts. We are now reducing the family to the minimum limit, and I don't say we can reconstitute it in the same way as the Balinese or the Mohammedan or Chinese family in a compound, but we could make it something other than the bare minimum.

HEDÉN: Certainly the bare minimum is one parent and one child. What I would like to find out is what are the experiences, not of the children, but of the adults in such groups, the sort of pecking order that always exists. Does it not put the individuals in such groups in a rather tricky position most of the time? I can visualize that in such groups, dominating individuals could exploit others who are less so. This worries me from the point of view of what we were discussing before—giving every individual the best chance. What happens?

SIMON: There is a problem in trying to face social change on two levels; one, to try to figure out all these things on the horizon that are important for the future, and at the same time to look at the crisis of the persent to really lay down guidelines on how you pick and choose. The second thing is that as the rate of change accelerates the real problem is that we're all living in worlds that tend not to resemble the worlds we are familiar with.

Take, for example, the original generation who created the *kibbutz* in Israel. This was very discontinuous, as a matter of fact, and fundamentally they had to use ideology to hold it together. It's only with the second generation, to whom the *kibbutz* was a natural environment, albeit something they assumed that we now begin to see something about the character structures

that might emerge in that social context. In defining these experimental families, or attempted experimental families, you have a similar problem of people who live together in relationships for which their pasts have not really prepared them.

For me one of the big distinctions is really the social-cultural imagery that imprints on personality. I think that much of our prior sense of self in the emergence of the industrial society is really very Adam-Smithish, and the analogues between Freud and Smith are very, very clear. A fundamental sense of something like intimacy—you had to have property, market-like qualities: A is intimate with B, and B is diminished thereby; he's getting a poor bargain. There is, however, also a sort of Keynesian intimacy—the more you spend the more you have. But I think there's a lot of pathology in all of this; what we need is a chance to look at it very carefully and hope that in five years we will tentatively pull away the pathology from the prototype.

EMILY MUDD: I think we have another type of practice going on willy-nilly in our culture. I have been working recently with pregnant black women in a prenatal clinic. One of the things is that at least a fourth or a fifth of them are not, in our sense, at all married. They have one or two or three children by the time they're 25. Most are on welfare, many on mothers' assistance. But the rules for mothers' assistance are that you can't get your allotment if you have a man in the family. So what happens is that these women don't want to get married, because if they get married they lose their mothers' assistance. We then have a government regulation, which is kind of an experiment within our own culture, and which I think no one has really studied. These women and children, almost all with whom I've had contact, live in two-generation female families. They live with their mothers, who may also be on welfare. There is no permanent male; the male comes and goes for sexual relations. What does a young boy in this kind of environment, especially in a minority group—what kind of thing are we doing in terms of hundreds of thousands of children?

CANCRO: Let me first respond to the last point that Professor Mudd made. The fact is that the black family *has* been studied a great deal in the United States; they have become pretty sensitive about it, and they're sick and tired of being researched. There is much that is valid in these studies in one sense. If one says that the point of this family is to fit this youngster into society, it sure as hell isn't doing the job very well. But if you say it is only one element in an interconnecting network, or one mode, to prepare this child to fit into society, then you can't say that the problem is as clear. You can only say that this mode differs from the comparable mode in a different network, and whether that's the cause of the problem or not isn't so clear.

To get back to Dr. Simon's point, if you want to look at the communes that exist now it's going to be very, very hard, because it's a question of the kind of society those kids are being prepared to go into. The answer is "None."

We've seen kids in psychiatric wards, who were raised in these communities, who were splintered, actually splintered, because when they came out they weren't prepared for any world that exists for us. This doesn't mean that the communes may not have something of value. I see them as a prototype of one kind of social unit, and we'll have a greater diversity of social units to perform some of the functions that are traditionally performed by the single family unit.

SIMON: I can conclude with one sentence: We still may have to live without the community. The community may be a very cultural-specific concept,

as a matter of fact, and it may be a dangerous concept, and crucial to social values.

MOORE: I'm very attracted to this notion of a functional approach to family. One thing we have not yet talked about, and I have a great sense of inevitability about it, is the role family plays now as an economic unit. I think we ought to consider the kinds of family structure that make profound shifts in terms of the support of the children; of the role of the wife, for example, and the job market. Maybe some of these impacts will be very good, but they could have decided impacts on society.

My second point really goes back to something that Dr. Mudd raised, which is very intriguing, and that is: Why are some laws counterproductive? Here we have a case where there can't be a man in the family. I think the Supreme Court decided that that was unconstitutional, and if so, it's been a little benign in its intervention. Here the law is really mirroring the deeply held commitments and values of the community. I think it's worth reflecting on that.

ERAJ: Whatever we discuss here has to do mainly with our own point of view. I have to say that outside this room people still regard the family as a unit. It's not just an economic-survival unit, either; it's more than that. Outside of this room people are still prepared to consider what they call religion; what has it given to them, and what are the chances of its survival? We are taking one aspect of what we call a family. We have to start on something, and there's no use running away from it. This is the concept that still prevails, except among a very, very few intellectuals. So I think we have been running far away from what is practical and what is realistic.

CANCRO: Perhaps I didn't make myself clear. I said the historical function of family, initially, was biological survival, and on this a number of things have been grafted. There are the psychological and religious aspects, and many other kinds of things, so that today it no longer is a simple biological survival mechanism.

ERAJ: I do think it is a biological unit, but much more than that, also.

HEDÉN: I think we don't differ much. Essentially it's a question of where we put our focus, and I think the function of this Conference is to try to extrapolate into the future in such a way that one can get these forms for people who are concerned with what the future requires as far as value is concerned. It is not the problems of the family of today that concern us, because they concern every other structure. We are looking at trends.

WADDINGTON: I think it's important to emphasize that we are thinking in terms of formulating questions, not formulating statements about all the vast variety of families. I wanted to make one point that hasn't been adequately considered, and that is that from the biological point of view man is not only an entity with an individual life history of development from egg or fetus to infant to adult and grandfather, so to speak; he's also an element in an evolutionary sequence, which is a sequence continuing in many directions. If there are to be sociogenetic correlates for all the biological genetic factors in man's makeup, then there must be a sociogenetic correlate of his evolutionary nature, as well as his embryological developmental nature.

We talked a lot about functions of the family, or family life structures, in the individual development of the personality of a particular individual; it seems to me we also need to consider that there must be social arrangement of family life, let's say, which subserves his evolutionary nature. I believe

that one of the functions of the traditional family was that the presence of grandparents gave a certain insistence on the fact that an individual is a member of an ongoing sequence of individuals in an evolutionary stretch of time. This seems to me to amount to another reason why some analogue of the extended family sounds more biologically satisfactory.

HEDÉN: May I start by directing a question to Dr. Moore, because I think that one interesting and important aspect is, of course, what particular speculations we would, as biologists, like to see recommended by lawyers? What are the things that you see, Dr. Moore, in our discussions that are of particular significance for us?

MOORE: It's really hard to respond, because I think that the answer is just about anything with profound possibilities for legal structures; most of them, of course, require the kinds of shifts that would have to take place, initially—or at least ones that we ought to be prepared for. In viewing the family, for example; there are no institutions and no laws today to say what would happen to the child in the commune. Suppose a child-support suit should arise. What happens? Suppose a member of the commune dies; where would her property go? There's a whole range of the kinds of economic qualities the law has been responding to. Suppose there's a breakthrough in aging research, for example, and it's a very extensive breakthrough. How does the law deal with that, as to the selection process for participation?

The kind of free association we're doing has suggested something that is a critical problem right now, and that is that as you get into a more sophisticated medical technology, more and more is money required; how will the cost be met? Where does the money come from? What part of society should say that one-third of our resources will be allocated to keeping people alive, for example, on a large scale? Where and how are decisions going to be made as to that kind of priority? These are really extraordinarily hard decisions to make. There is pollution control also, of course, and directing environmental problems. That's a little easier for us, because we already have a kind of crude common-law structure in the nuisance theory, and we have agencies and conditions we're familiar with to try to control the issue. So we can see that in institutional terms, setting up the right kinds of institutions to be responsive to new technology would provide the right kinds of policy questions.

SIMON: But we can raise the question: What kinds of problems is this going to raise for us, because at present we obviously want to build a bias, even if the bias is only to maintain a very restricted definition of the family. I think the whole structure of what we want is to address ourselves to the question of how acceptable the legal institutions that emerge in the next generation or so will be, and how they can become more responsive.

MOORE: Quite true, and I think when you demand that you are really demanding that society become more responsive to the law; you're dealing with deeply held mores and values, and with people.

WADDINGTON: From a worldwide perspective, we have to realize there are quite a number of different kinds of family, and *we're* talking largely about the Christian, monogamous, Western European basis of the family. There are other family structures in other parts of the world. I would say that law, again on a worldwide basis, is not really based on defending one's particular kind of family, but it defends the kinds of experience about one's family, and we know, more or less, after several centuries of experience,

what tends to happen to people brought up in monogamous Christian families.

I think an interesting legal problem arises: Can one find any defense for the children brought up in experimental types of families where nobody knows what's going to happen to them? Some of the new types of family arrangements are being made primarily for the benefit, or at the instigation, of the young adults who are taking part in them, and this means that the children are brought up in ways in which we have little experience about what happens to their character structure. I think Dr. Cancro mentioned that some of the children in some of the communes come out with splintered personalities, not prepared for any type of real life they're going to find outside the commune. Now, this is very injurious to children. Is there any way, or should there be any way, in which they can be protected against their parents' making experiments on them with devastating consequences?

CANCRO: This is, I think, a morally important point. There is a terribly important moral, medical, ethical question in doing experimentation in a completely uncontrolled manner in which the consequences of the experimentation are borne by someone who is biologically and psychologically unable to give informed consent. It may work out well in a given case, in which you can say, "That's fine," but this in no way vitiates the moral issue. You might say, "I shot at you, but no hard feelings—I missed." It means only I'm a lousy shot. What I did was still a dangerous act.

This kind of experimentation is dangerous in a very real sense, because if harm is done we don't have effective techniques for undoing it; our techniques for undoing the harm that's done by existing, known social organizations is quite limited. Then, if you bring me someone who has been raised on Mars, I don't know where to begin. The difficulty we have with many of the young people who come seeking treatment is that they haven't got the problems for which we have the experience. All we can say is, "Sorry! You're myopic, and we have lenses only for farsightedness, so send your brother around; we'll do something for him." This is not a medically enriching experience, especially since many people are young and engaging and intelligent and attractive, and you feel like a horse's rump when all you can do is mouth some platitude and wish they'd go away. I do want to raise the question of how one can build in some kind of moral sense about what happens to the offspring of these experiments.

SIMON: I think you're making a critical mistake, because you're demanding that the new pay a higher price than the old. Parents who are merely religious fanatics destroy their children. Lawrence argues that the propensity to neurotic symptom formation is universal; nobody survives his parents without them.

CANCRO: But you see, from his point of view, neurosis is not illness; childhood neurosis is a developmental phase necessary to go through.

SIMON: At any rate, you're trying to make the new pay a higher price than the old, and this is a kind of very dangerous conservatism.

CANCRO: No, this is radicalism, demanding more.

SIMON: What you're saying is: "Before we'll let you go ahead and try this, we want you to provide us with more guarantee about the outcome."

CANCRO: This is at a higher risk.

SIMON: Then it's a higher risk only because of the standards you have, which is something that shows up in my practice. I can be raised by

puritanical, 19th-century souls who make a compulsive neurotic out of me; I may be a terribly successful academic lawyer, a wretchedly unhappy person, a dangerous man to have voting or to be put into a future society.

NG: Let me pursue this in another context. The youth, for example, say, "The establishment is something we want to get rid of," and let's say that one of the traditional structures is a bank. Now, which is more immoral, the burning of the bank or the founding of the bank? The founding of the bank goes 'way back. The burning of the bank is a new approach. Which has to pay a higher price, the new or the old? I have no answer for this.

Now, going back and making a generalization from the question you raised about experimentation on specific human beings: The whole human race is actually being experimented on whether we like it or not. We have been experimented on from the first time that the theologians and politicians experimented, and I'm talking about this, from a very scientific perspective. I can mention one word here and make everyone in this room furious. What does this mean? We are only beginning to be able to build scientific instruments that can produce the same end point. I can put a needle in the hypothalamus and produce the same rage response.

A word is a much more sophisticated thing, and that is a social experimentation that has been going on for centuries. It raises certain personal and ethical questions, as to whether I put a needle into your brain and get a rage response. How is that different, I want to ask, from putting a needle into you—which we will soon be able to do—and produce responses of this type? The scenario is going to be slightly different and modified, perhaps, to an even cruder scale. The other point I wanted to mention is that even with the best intentions, and perhaps this is a human condition, we end up with the result that we set out not to get. The population problem today is the result of the good intentions of international agencies—to wipe out malaria. This is a beautiful intention, but we were not able to foresee the consequences, even with the most brilliant minds, at the time that we started doing it.

The Atomic Energy Commission exploded nuclear devices in outer space, and perhaps they were keeping the information from us at the time, but we were assured that there was no danger from fallout. But they had no control over the tides and the wind, so that most of the nuclear radiation was concentrated on the Temperate Zone and on densely populated areas. There is the same problem with DDT. We could not know that it would end up with the results that we now have. This is another moral question that should be raised.

WADDINGTON: I don't know what you deduce from this; it's quite clear that we can't always foretell the results of our actions, which always has been and always will be true. But are we deducing, therefore, that we should never do anything that we haven't done before?

NG: No, I'm just raising the question.

CALHOUN: I'd like to raise a basic question: are we concerned with survival or evolution?

WADDINGTON: Survival of what?

CALHOUN: What is survival and what is evolution? You suggested, in your initial comments, that there must be something in the makeup of man that has to do with continuing evolution. And, in your phraseology, this implies that

there is something in the total genetic template, in its diversity of organization, that will sustain evolution. That raises the question of the template, which comes back to Dr. Moore, that the law is, in a way, within the mechanism of the templates that serve evolution. It's a dichotomy that to evolve you have to survive, but then we have to define what evolution is beyond mere natural selection. Is there some neo-orthogenesis that gives direction? Is it the way that evolution has to do with progressive development of something that we call "brain," which is the organization of elements for the acquisition-transfer-storage-transformation of information?

This is where we are, and it is some criterion if we can take evolution and make a definition that encompasses biology and culture to provide a basis for jurisprudence. I think first of survival and then of evolution. There is, somehow, a basic question that gets in both survival and evolution as a guiding principle by which we orient other decisions.

WADDINGTON: Could I try to paraphrase what I have understood from your remarks? You are saying that the law has the function of perpetuating certain social relations longer than the mere interrelation between two people. It is codification of social relation—say family structure, if you like—longer than the relation between one parent and his child. It is the long-term template.

And then Dr. Simon pointed out that any such long-term—paraphrasing him—any such attempt to perpetuate relations longer than those between two individuals necessarily implies that the new, which is breaking the relation, is going to find more difficulty than the old. This happens, of course, in biological evolution; a mutation has much more likelihood of being weeded out by natural selection than the genes already existing in the population. I think one might pose the question: If one takes it that the law regulates the relation between people, that it regulates them in relation to longer-term trends of society, how do we balance these two functions of the law to allow new types—to give certain freedom to new types of relations while at the same time preserving some continuity?

MOORE: Let me try to respond to that and to some other things as well. I find somewhat disturbing the notion that either newness or oldness is an adequate or proper basis for ethical judgment. I also find somewhat disturbing the notion that—just because there are things we don't like in society, or that some parents raise their children in a maner we think quite destructive—perhaps society ought to contemplate taking children away from parents; that justifies a refusal to look at other situations that may also present serious ethical problems.

To me there is no escape from individual choice in all of these cases. If I had it demonstrated to me that children brought up in some kinds of new experimental systems tend to deviate from the norms society itself has set forth, whether good or bad, that it has happened to them without their informed consent, I'd like to know if they would have made that choice initially, had it been placed before them. Without our saying that it's necessarily good or bad, it does present a serious ethical question that we can't sweep under the rug.

In terms of the functions of law: Law does tend to take a long-range interest, but it performs many other functions as well, a societal intervention to mediate, in both the short run and the long run. We have cases that come up that are never really duplicated and don't reflect any kind of long-run rules. The problem of adapting the legal system to change is something that is the heart of problems of law, and the only answer is that it is something to be struggled with every day to make it responsive to change. I think it's more a question of the political system itself than of the particular kinds of expertise in law, although there are certain areas that are of low visibility to lawyers, just as there are ethical judgments and decisions that are of low visibility to doctors.

HEDÉN: I'd like to bring in at this point something we discussed before. It's important to consider two types of law; one, which is singularly important because of the impact that ecology should have, is international law. International law is composed of codified law of different types, plus a sort of customary law that has developed through the ages. Certainly the customary law should take ecological things much more into consideration. I think it would be very appropriate at this time to point to this issue, because a lot of the thinking that goes into the formulation of international law is singularly devoid of biological consideration. I would say, for instance, that one should raise questions like this: Suppose there is something with genetic effects, is it acceptable to withdraw its use to a larger extent with regard to one population gene pool than with regard to another that is exposed to its effects?

WADDINGTON: Aren't we getting a bit far from the family? I think we had better try to keep it down to the family at this point.

HEDÉN: But we are making ethical considerations.

SIMON: I have a question that's linked with some of our earlier concerns, also involving the interaction between the biological sciences and the social sciences; It's the question of the quality of life, the family, and gender identification. So much of what is in family law reflects an antiquated sense of natural law, quote, "natural," presumed natural gender distinctions, which may not be very natural. While talking about the family, we really haven't talked about what gender roles might mean; what kind of possible changes in gender role formation are on the horizon.

CANCRO: I agree with Dr. Moore about the moral relativism; I think it is an incredible argument to say that someone else has done something worse. I think any murderer can at least point his finger at Hitler; Hitler could point his finger at Stalin and say, "You see, by comparison, I'm a humanist." I think it's an absurd position. Now, there are many questions I would like to raise with the group, but four come immediately to mind.

The first is: What functions does the family serve in a given culture? The second: Are each of these functions best served by a given type of social organization in that culture? The third: Should the functions of childbearing and child rearing be separated? This has certain important implications, because certainly we are further away from liberating women from childbearing functions than from child-rearing functions. The fourth: Should children be reared with an emphasis on maximum group independence or dependence? I don't know whether the last question is clear. What I'm thinking of is whether there's some individuality in growing in your own unique manner as opposed to a community or group manner, where the subject gives up some individual desires in favor of the group.

WADDINGTON: I wonder whether these aren't too specific questions for us to respond to in any group?

What are the functions of the family in a given culture? Well, there's a vast anthropological literature on this. Is each of these functions best served by the type of family in a particular culture? This is a more general question, but again you have to explore a mass of the anthropological literature and discuss each function. Then again, should the functions of child rearing and childbear-

ing be separated—and I think that this sort of interdisciplinary group, made up not particularly of anthropologists, could really better formulate some much more general questions—if we can think of them.

HOTCHKISS: What chance is there that man is imprinted, in a sense, before a certain hour in his life and from then on, throughout his entire life, is affected by it. These are absolutes that can enter the picture, and I wonder if we'll be able to recognize any of them, or if we are all subject to them or subject to one or two alternative states. This is something that may be taking place in the family—early in the family life—and to a great extent in the shaping of its culture and function.

WADDINGTON: I should have thought the diversity of cultures in living situations is such that the shaping would have been picked up if it does occur.

HOTCHKISS: But we've always assumed that man is adaptive. If we were subject to such imprinting, we'd say that this is the nature of things, this is the way things are; even in different cultures, with different inputs, this would be so.

WADDINGTON: You might say that you get imprints with language, meaning complications can be conveyed through sound. Whether this can be regarded as imprinting I'm not sure. The question I want to put is: What types of reproductivity reinforce the evolutionary consciousness of man as far as his developmental processes are concerned? We say so often that man must now take control of his evolution. It seems to me some types of family structure might well result in man's being scarcely aware that he is in the process of evolution. So that would be my question.

HOTCHKISS: Dr. Simon said most of us find life very different from the life we are prepared for; it struck me that there is a parallel in something Dr. Calhoun said, that we are living in a physical world in which we're genetically not too well evolved, and many of the physical and societal impingements are not suited to our biological endowments, and medicine will have to take this more and more into account. I think we are saying that society and law are also being used, in part, to reconcile or harmonize these inequalities—that is, the genetic and the psychological-educational early training.

WADDINGTON: Could we ask: How far is the right of progress and social arrangement limited by the fact that character structure is so determined in the first few years of life and is so difficult to change later? This is a point I don't think we understand; how quickly can you actually change a society's general outlook?

CANCRO: Another outgrowth of that would be the correspondence between the rate of change in the environment as opposed to the rate of change intra-individually and in social institutions. Is the rate of change in an individual and the rate of change in social institutions out of tempo with the rate of change in the environment? The world is certainly changing faster than our institutions are.

STUART MUDD: It seems to me that one of the difficulties we face is that our allegiances, our loyalties, are too parochial, too narrow, too restrictive. I wonder if we couldn't affirm in some way that these narrow allegiances are no longer valid in a world that has become unitary, global, and concerned; could we affirm that we should try to inculcate a broader, more global, allegiance very early in life as a basis for a character of world man?

WADDINGTON: That could link up with the question: What types of family life and reproductive units reinforce man's conscious awareness of his evolutionary nature or citizenship of mankind as a whole? It's almost the same point as the evolutionary one.

EMILY MUDD: We could also head into this from another angle: How much of our medical services, including our psychological services, try to mold the individual in the grooves of a social structure that is far from ideal and is changing far faster than our legal institutions?

NG: What values or systems of values can we begin to identify that would be transnational and that would facilitate the expansion of the consciousness that has to be acquired in order to regard the human race as a unit?

WADDINGTON: Can you relate that to the family?

NG: Perhaps the family as a unit will become extinct. I am just suggesting that it's appropriate at this time to consider the evolution of the family, but also, perhaps, including in the context the possibility that the family as a unit may evolve into a totally different thing.

WADDINGTON: But I think one has to take it that a newborn baby has to be brought into the human family, the human race. At the moment, it's brought into the human race by the influence of what we call its immediate family. But there's no reason to believe there's any instinct that's going to spontaneously be able to give its loyalty to the human race or to anything else in particular. It acquires its loyalties while it's developing. If one abolishes the family entities now one has got to put in its place something that initiates the newborn baby into the social-cultural world.

STUART MUDD: We might affirm that social institutions and educational procedures should be developed in such a way that acculturation within the family would represent an allegiance to large units—the kids on the same block, or the school, the class—and grow up through a series of expanding allegiances. Can we so arrange things that the acculturation within the family, or whatever group takes the place of the family, is responsive to the need for a broader allegiance and a larger body that will be global, not parochial?

WADDINGTON: I think we'll put this in the form of a question. What types of family life reproductive units reinforce man's conscious awareness of his evolutionary nature and his citizenship of mankind as a whole?

* * *

REPORT OF THE WORKING GROUP ON POPULATION, HEALTH, AND FAMILY

Rapporteur: John Norton Moore

In responding to threats to man and his environment, a central concern is to make optimum provision for individual man while moving toward more effective and comprehensive planning for protection of the biosphere. In keeping with this emphasis on individual man, the group on Population, Health and Family recommends that the Conference consider the following goals and strategies for their implementation.

Goals for the Well-Being of Individual Man

The International Covenant on Human Rights adopted by the General Assembly of the United Nations codifies the common aspirations of mankind. Such development includes rights to adequate food, education, and employment, improvement of living conditions, receipt of benefits of scientific progress, and the highest attainable standards of physical and mental health. It seems useful to supplement these statements on human rights with a more explicit biological bill of rights for the individual man. Such a bill of rights should include:

1. The right to an adequate food supply, free from toxic additives or pollutants.
2. The right to have clothing and shelter consonant with physiological and aesthetic requirements.
3. The right to live in an equitable physical environment, aesthetically attractive and physiologically healthful.
4. The right to an upbringing that does not emotionally malform and does lay the basis for healthy psychological development.
5. The right to education continuing as desired throughout life, the aim of education to be the growth and development of the individual to the fullest extent of capacity and interest.
6. The right to live in an equitable psychological environment, characterized by respect for human dignity and diversity.
7. The opportunity for creative work and self-development at all stages of life.
8. The right to adequate medical care.

Strategies for Implementation

The range of problems in realizing the full capacity of individual man suggests a need for continuing inquiry into strategies for implementation of all the desired goals. As preliminary recommendations, however, the Working Group on Population, Health, and Family would single out the need for comprehensive planning and research for dealing with population problems, the need for internationally based research for investigation of physiological and

behavioral effects of environmental insults, the need for continued development of adequate health-care delivery systems, and the need for continued inquiry into the role of the family in individual and social development. The Working Group also recommends the establishment of a Commission within the structure of the World University for continuing inquiry into problems of man and his environment, in collaboration with the International Council of Scientific Unions, if possible.

A. Population Policy

The task of meaningful implementation on a global basis of minimum human rights to psychological and physiological development is staggering. Even at present world population levels, such implementation will require unprecedented scientific, technological, and political efforts. Despite expected scientific and technological advances, however, the present exponential increase in world population, if unchecked, threatens within a generation to make the realization of these rights unattainable and to condemn a large segment of mankind to a stunted existence.

Accordingly, it is urgent that decision makers at every level—national, regional and global—give immediate attention to the development of institutions and strategies for ensuring a stable population or a rate of increase that will permit a sustainable realization of the fundamental biological rights of man. It is particularly recommended that every nation establish institutional mechanisms charged with the responsibility of developing and implementing an appropriate national response to population problems.

In implementing strategies for population control, it should be recognized that the realization of fundamental human rights may be served by differing policies of population numbers and rates of change in different nations and regions. All such policies, however, should take into account the ultimate interdependence of all mankind in sharing the limited resources of our earth-space environment and should be based realistically on regional differences responsive to the basic biological rights of man. In implementing strategies, it is also preferable to utilize noncoercive techniques of control that promote informed individual choice and to recognize that some strategies, such as family planning, may promote important human rights quite apart from their utilization as techniques of population control. We recommend that necessary research to develop and implement more effective and acceptable techniques of conception control consistent with safety be encouraged.

Consideration of the complexities of the cultural, psychological, and political factors in formulating effective population policies must not be ignored in a rush to realize instant panacea solutions. Indeed, cultural and psychological factors may be the most critical variables in effective implementation of population policies. There is also a responsibility to consider the social implications of societal intervention to control population and its linkage with other problems, and to design sufficiently broad-based policies and institutions to make these policies effective in achieving the basic goals. In spite of the difficulties in formulating optimum policies, however, it is critical that national and global decision makers accurately perceive the magnitude of the present crisis and the limited time available for solution.

B. Research in Effects of Environmental Insults

Though there is substantial research directed at gross pathological changes, there is a need for greater emphasis on research into the genetic and behavioral effects of low levels of environmental agents. Such research could study the more subtle effects of chemical and other factors introduced into the environment, including the synergistic effects resulting from interactions among potentially deleterious substances. To generalize, the environment has in large measure been medically cleansed of the grosser natural environmental hazards, or the information is available to do so. The task for the future, then, is both to cleanse the environment of the most subtle natural contaminants and to protect it from the introduction of new artificial agents.

The scale of investigations necessary to assess adequately the effect of low dosages and complex interactions among factors suggests that internationally based research may be more effective. Possibilities for consideration are the establishment of global data banks focused on the pathological effects of low-level environmental pollutants, establishment of new international laboratories, and conversion of certain existing national laboratories to international use.

C. Health and Well-Being

The Working Group discussed the future development of effective services concerned with human health and well-being. It concluded that the topics most in need of further study were:

1. The need to restructure health care in both developed and developing regions so that satisfactory services could be provided. Such services should focus both on healthy development and on care of the sick. In doing so, they should not make too great demands on the capacity of the educational system to produce high-level specialists.
2. The great importance of more adequate education of the public in basic biology, including physiology and genetics.
3. A more satisfactory balance of the needs for specialists and generalists in the health-care professions.
4. The desirability of a greater emphasis in research policy on problems of normal life (maturation, aging) as compared with disease-oriented processes.

D. The Role of the Family

The Working Group discussed the role of the family in individual and social development. It concluded that family structure is important for a range of functions, including childbearing, child rearing, and psychological and economic needs of family members. It also concluded there is a need for continued research into the range of functions performed by the family in particular cultures and exploration of alternative modes of family organization and other strategies for effective realization of those functions. The Working Group was particularly concerned that attention be focused on the ethical implications of existing and alternative types of family organization. Similarly, attention should also be given to the adequacy of the present legal structure for the regulation of the family to ensure that changes needed for full realization of individual and social potential are realized.

Establishment of a Continuing Mechanism for Inquiry into Environment and Well-Being

The urgency and complexity of the problems of environment and health care suggest a need for a continuing mechanism of inquiry into their social and policy implications. One appropriate action mechanism would be an interdisciplinary commission established within the framework of the World University. Accordingly, the Working Group recommends that an interdisciplinary commission be named as soon as possible to consider both environmental and health care problems and to make appropriate policy recommendations. The Commission could function on a continuing basis within the framework of the World University and could carry forward its task by commissioning appropriate studies, establishing relevant committees, holding periodic meetings, or engaging in other activities deemed useful to its principal functions. Among other issues, the Commission might address itself to implementation of the recommendations made by the Working Groups and to clarification of the range of issues adverted to but not fully explored at the Joint Conference.

If possible, the Commission might also collaborate with the International Council of Scientific Unions and should explore the possibility of establishing other linkages with concerned institutions and professional associations.

Working Group
SCIENTIFIC KNOWLEDGE, EDUCATION, AND COMMUNICATION

Cochairmen: Ernst Bergmann, Henry R. Cassirer, Erika Landau, Margaret Mead

Participants: Jean Baugniet, Martin Blaser, Eskil Block, Jorif Brandt, Edward R. Dewey, Hugh Goitein, Ervand G. Kogbetliantz, Robert E. Marschak, Lloyd L. Morain, Arthur Porter, W. Michael Reisman, J. Arnold Roze, Arne Tiselius, Heinz von Foerster, James Wellesley-Wesley

CASSIRER: I have two comments in reference to the extent to which experience of social communication of each age group differs. I don't think it is a question of age groups but a question of social groups and social-group communication. I am thinking of social classes within society. I am thinking of different societies in the world and not just a generation gap. There is a social gap in communication.

ROZE: I wonder if we are talking not so much about social communication but what used to be called the "educational process," where there is a teacher and a student.

CASSIRER: I am well aware that we are talking about education. But consider a cultural ministry, which disseminates information. This is education, of course, but they don't know what is going on. The people who are living on the land have their own point of view, and it is a very different point. Therefore, there is a social gap between those in policy positions and those who are the objects of policy. This applies just as much to education as the age gap does.

LANDAU: I would like to say that we should consider ways of suggesting an approach to future creativity and innovation and consider how institutions should teach this. The creative and innovative approach to science, to research, is already known. Where it has been tried, children by the age of eight are already doing very well. Those are things that we should state in our report and should go into in some detail. I disagree quite strongly with one statement suggested to us for inclusion in our final report, and that is related to a demand for abstention from acts binding in the future: this is quite impossible. Every act you commit binds your future.

BLASER: I think what was intended were those acts that are irreversible and cause irreparable damage.

LANDAU: Maybe we would want to say "close consideration of any act that would bind the future." We have in every big city streets that are 300 years old and will remain for 300 years more. This is a binding decision.

* For technical reasons beyond the control of the organizers of the Conference, or the editors of these proceedings, complete records of this Working Group's deliberations were not available. Therefore, the comments begin after the meeting was in session. Subsequent portions of the available transcript, therefore, also had to be omitted.

UNIDENTIFIED DISCUSSANT: We must consider the implications for the future.

CASSIRER: I think this was a reference to genetic engineering, which means decisions of a kind that would certainly be irreversible. And I think it is from the point of view, perhaps, of reversibility. A street can be reversed, but genetic interference cannot be.

DEWEY: As I see this, we are considering, first, the idea of the formation of a new institution, and then, illustrations of what such an institution might be. The key to it, I think, is whether forming a new institution is the sense of the meeting.

TISELIUS: Is the idea that this new organization—whatever it is to be called, wherever it is to be, whoever is going to sponsor it—is the idea that this organization will coordinate all the work that is being done in future research? Some of you may have read John McHale's very interesting book, The Future of the Future, in which he lists a number of organizations in different countries and of different types now doing very efficient work on the field of the futures, as such. But what this new organization could do would either be to try to be a coordinating center for this work or to limit itself to some neglected areas. I am not sufficiently familiar with the matter, but I can imagine that perhaps in the field of education not enough is being done. I think this has to be clarified.

In any case, I would like to further stress that this organization will be highly dependent on other work that is being done today and that there is perhaps not enough contact between all of these organizations, both in this country and in Europe. There are at least 50 or more committees, in the academies and organized independently by private societies, looking at these problems.

LANDAU: There are very interesting developments in Czechoslovakia. Much is going on in education, and they are beginning, in some institutions, to consider problems of the future. Everything is still fermenting, still in flux. But it is generating.

UNIDENTIFIED DISCUSSANT: All such studies and efforts are in experimental stages, and we should not have any hesitation about bringing in what we know is important.

UNIDENTIFIED DISCUSSANT: If there are partially neglected areas in considerations of the future, we should certainly hear about them and stress the necessity of doing something. Some people fear that we will tend to duplicate what is already being done. The need for this work is so great that we don't have to have any inhibitions or fear that we might duplicate it.

BLASER: Then we should proceed to specify proposals. We should break into subgroups; and if we could have four or five people in each group, and then have a report on the concrete proposals, we can, perhaps, accomplish a fair amount.

UNIDENTIFIED DISCUSSANT: We should remember Dr. Tiselius' proposal to set up some model that can be copied for any kind of teaching or research anywhere in the world.

UNIDENTIFIED DISCUSSANT: Couldn't we call it something else? The model of teaching may be technology or philosophy or whatever, but by no means should we put it into strict frame, because it forces us into a strict categorizing procedure.

BLASER: The members of each subgroup can decide on whatever title they wish and whatever the relevant idea is.

UNIDENTIFIED DISCUSSANT: I think that humanization of technology and establishment of model teaching institutions should be discussed together because of the need for an interdisciplinary approach.

CASSIRER: Maybe we should keep them separate, because there are two ways to look at them. One would be from an educational standpoint, and the other would be what we can do now economically, politically, et cetera, to achieve a humanization of technology.

UNIDENTIFIED DISCUSSANT: We were discussing earlier, for instance, the problem of the possession of monopoly over television and mass media. There are countries where the government owns it and countries where it is left to commercial interests. Dr. Cassirer said this is only one problem. There is a much bigger political and economic problem: how should we use technology? I think this is not so much an educational problem as a political one.

(Following are excerpts from the discussions in each of the three subgroups. Each group is preceded by three asterisks.)

* * *

CASSIRER: In talking about the dissemination of knowledge, the first question is, "what do we mean by knowledge?" There is a tendency here to identify knowledge with science, but in terms of the humanization of science, I think we have to go beyond that. We must conceive of knowledge as the knowledge of science, the knowledge of experience. And the knowledge of experience is by no means limited to the academic community. In fact, the knowledge of experience is frequently found outside the academic community in a far more creative and solid way. What is the distinction between knowledge and values? Are values part of knowledge?

ROZE: Values are something built on the knowledge and experiential framework but express themselves in that framework.

CASSIRER: If we take knowledge in this broad sense, then I think there are two dimensions to its dissemination. One is its dissemination to others whose primary concern is knowledge—which is, of course, the academic, professional community of the world. If you reside in Lagos, or London, or Peru, you want to be able to share in man's knowledge, and share in it not only by benefiting from it but by contributing, share by doing research where you are, share by a confrontation of ideas. This raises the question of an international communications system in the field of knowledge, which, to me, is one of primary importance when we talk about a world university. That's the difference between a world approach to a university within a university and a world approach to a university in which are truly reflected different institutions and different backgrounds of experience.

The other aspect of dissemination is the relationship of knowledge to people and to policy so that people are aware of what knowledge is, can use knowledge, can influence knowledge, can influence the direction of knowledge (which they do anyway, through the application of funds). It is the same for environment. Are we willing to pay the high cost of electricity for the sake of a clean environment? These are not all issues for the knowledge people but are issues for society.

Then we have the question: How do we create an interchange of knowledge between the people whose profession is academic knowledge—those people who

are not only the objectives of knowledge but the possessors of knowledge in a different way? Those people have knowledge. Youth has knowledge. Youth has its own approach to knowledge. The young know that this society does not give them what they want. If you went to a marketplace in Africa and asked 16- and 17-year-old people, "What are you going to do?" They would say, "I don't know what I am going to do, because I have no work, I have no access to the society." That is their knowledge. Their knowledge has to come to us, and I think this has implications for communication and implications for education.

I would like to spell out these implications. One is a worldwide communications structure that permits the interchange of knowledge between people, not just through computers, but through satellites, through media recordings. There are many means of confrontation, even if we don't have physical confrontation, and we are not exploiting this resource. The other implication is the use of communications media for disseminating information to people and, further, for getting back from people reactions to issues that are close to them.

ROZE: I think Dr. Cassirer touched on all the basic points. First, obviously, we agree that there are two aspects that are one and the same. Much is communicated, namely, the content of communication. The problem is the medium through which it is communicated. The technology we can leave more or less separate, because we are not going to deal with it. We are interested in the media of communication to the extent to which a feedback system exists between the technological aspect of communication and that which is communicated.

CASSIRER: I am sorry; I don't understand this. A feedback system between the technological system and that which is communicated?

ROZE: Right. The available time of communication influences the content of what is communicated. That is one feedback we have recognized; the knowledge that we are communicating, or the information that we are communicating, to some extent, is influenced by the medium that we use.

CASSIRER: Yes, but on the other hand, the method that we use is influenced by the content of what we want to communicate, because we have a whole gamut of media.

ROZE: But there *is* a feedback situation. If we look at the content of what is being communicated, we probably have to talk in terms of the identification of points that communicate. For example, scientists to scientists, scientists to public, public to scientists; that is with respect to the information part. Then there is the communication of experience that you mentioned, and that is in terms of sharing. So we have scientific knowledge, which is information about something, and then we have experiential knowledge, or experience that is shared, and interaction between two points that are communicating.

Let me make a very concrete framework. Today we have a situation in which the mass media have taken over and influence people instead of being utilized for the people in their need to advance. I am thinking of the man in the next ten or 20 years. What type of communication do we want? What definition should we give to it, to the elements that are being communicated and utilized? And what is the optimal use of the communication possibility or facility as such?

CASSIRER: Could you give me some illustration?

ROZE: A very concrete illustration would be the following: of course, at this stage, interdisciplinary communication is an isolated example, between science and science, and it does not work. Therefore, the communication that

has to come is between science and public, science and political bodies, science and economy, science and technology, and so on.

CASSIRER: But scientist-to-scientist is also very important.

ROZE: I say that today that is what is predominant.

CASSIRER: Even that isn't taking place, because you have communications between specialist and specialist but not communication between scientist and scientist.

BLOCK: I would like to express a somewhat negative point of view in regard to Dr. Cassirer's eloquent display of the communications we will need. It is a beautiful model, and one asks oneself, why is this not so? I ask myself what are the obstacles to communication? Where do they come from?

We have, first of all, private interests to guard our own knowledge—for instance, the secrets of the medical profession. You have political divisions that you don't wish to have communicated across the borders of a dictatorship. You have professional laziness, which gives rise to a lack of communication between the professions, and so on. The fact is that one *could* make such a list.

CASSIRER: I would be happy to do so. I would be very happy if we were to begin with the things we know; what we want to do about it, we cannot yet decide. So let us list the obstacles to dissemination of knowledge. We assume that knowledge has the broad interpretation—social knowledge, cultural knowledge, experiential knowledge—and that we are thinking of dissemination of knowledge both within and without the so-called knowledgeable community. What are the obstacles?

BLOCK: I would say, first, egotism. For instance, from the point of view of the individual and the company, which one might call the suboptimization. Some would simply like to seek all knowledge and not give it to others.

CASSIRER: This applies to the individual; this applies to the company; this applies to the institution; this applies to the country; this applies to the discipline. And, in fact, disciplines deliberately use confusing language so that nobody can understand. This is the monopolization of knowledge by fragments of the knowledgeable community.

BLOCK: That's the first obstacle. The second would be difficulties of language. There is, first, the additional languages. You have the language of the professions—which is, I think, not so much that they want to keep others out as that one simply—it is a lack of training and the limitations of the brain. One can't learn all the languages as one would wish, and therefore we have constantly to simplify these languages and draw them into each other. That would be the second obstacle.

CASSIRER: Are you speaking of the spoken languages or professional languages?

BLOCK: Both.

CASSIRER: All right, let us make a point: language, national and professional.

BLOCK: The third obstacle is political blinds, which is perhaps a form of egotism, but it has stronger implications: you want to control all flow of information, for instance, across national borders, because you want to create a society very different from that surrounding you. There are economic difficulties, for example, in certain countries where you cannot afford television.

CASSIRER: The economic obstacles are basic. We can't afford worldwide communication, but if we had worldwide communication, only certain countries would have access to it. This is one of the basic obstacles; we assume equal access to the communications of technology, which is not the case. So we have economic obstacles.

BLOCK: And technical.

CASSIRER: And technical obstacles. Then isn't there the obstacle of different approaches to things? There is a whole framework, entire groups of priorities that are completely different between the developing world and ours. These differences are social, cultural, and ideological.

The issue of DDT is a good example. We consider DDT to be harmful to humanity. Many people whom I have met recently say, "To hell with DDT's being harmful; we want more food, and therefore we want a different value." Our values *are* different. We have certain other social priorities, and because we have them, we have a different approach to the kind of knowledge that we want to develop and the kind of experience. So we have social and political obstacles, and not always in relation to dictatorships but in a sociopolitical context.

ROSE: There is another framework I think important, and that is the difference of national stereotypes, national attitudes; the entire area of the national cultural framework is definitely a great impediment.

CASSIRER: In any case, I don't believe that there is *one* knowledge. I think that if a basic assumption is that the whole world is going to think alike and is going to share all ideas and agree on all ideas—someone here has said, "You know, there must be objectivity that is applicable universally." I don't think there is universal objectivity; it would be static, and it would be a phony world, in the sense that the values of some would be imposed on others. We only have to look at Vietnam. We have cited the obstacles to knowledge among the knowledgeable community. What are the obstacles for knowledge dissemination to the people, to the society, between knowledge and society?

BLOCK: What about pedogogical obstacles, teaching methods, lack of adequate teaching methods for given problems? We have to develop, for instance, new technical methods for new teaching methods, for new media, or for new audiences. We need new organizational and educational methods.

ROZE: Which are lacking.

CASSIRER: We are lacking a method of dissemination that is meaningful to people, that is relevant. I think the first problem is simply that people literally don't have access to knowledge; they have no schoolrooms, they have no communications media. They may be illiterate, but that does not mean they can't learn. And if they are literate but have no radio or other means of communications, then knowledge is inevitably confined to the present communication. Second, there is a lack of relevance, of knowing how to communicate relevant knowledge. Third, there is the obstacle that the people who develop knowledge are not responsible to the people who have the experience. This is why we have demonstrations. This is why our political process does not provide two-way communications. People don't have access to knowledge, and knowledge has no access to the people.

BLOCK: In the mass media there are the experts, the professionals who make the programs but who have very little knowledge about the particular subject. And there are the people who want knowledge but are remote from it.

CASSIRER: And also the people who have different kinds of needs, who should have something to say as to what they want knowledge about. There is, for example, a way of disseminating information about family planning. But what the people want is not just knowledge about family planning; they want

knowledge about how to live together in the family. Therefore, they want knowledge about health, they want knowledge about relationships between parents and people, they want knowledge about the relationship of the sexes, polygamy, a foreign word, or the state of the union. But how do the people tell us what they want? How do people get their point of view across to the people who are developing the knowledge? What challenge do we have?

KOGBETLIANTZ: A man from Kenya who works in birth control in his country said that he found it useful to start with barren women. When he helps them and they have children, other women come and say, "I have too many children." Then his prestige in the community increases and he is able to help the other women. If he had started by limiting births, people would have said, "You're trying to limit the number of Negroes."

CASSIRER: How do you keep your ear to the ground?

BLOCK: Market research, I should say.

ROZE: There is something I want to say, but I don't yet know how to define it. It is a lack of insight on the part of the scientist who has the knowledge to provide the service or the communication that is needed. An environmental attitude.

CASSIRER: The scientist does not like to explain himself. He feels that his duty is to himself, to his own discipline. There is also a problem of dissemination of knowledge acquired in one part of the world to people in other parts of the world. And I don't mean only from the United States to others.

ROZE: That would be dissemination of knowledge to and from developed areas. That is a third topic, and we can focus on it if we want.

BLOCK: That doctor in Kenya has experience in Africa but knows nothing of the Catholic culture. He is in a part of the world where there is no religious leader in birth control.

CASSIRER: In Africa, you have a very strong emphasis against birth control from a racial point of view. In Latin America, you have the religious aspect; in Asia, the principal obstacle is simply that people know that children don't survive. And because only boys count, if you don't have at least three boys in the family, which means six or eight children, how do you know that any one is going to survive? Perhaps the technology of human eugenics might be applicable to Asia to make sure families have boys.

BLOCK: A question was raised in England by someone who came from Assam. He said, "If you Westerners can provide us with the technology where we are sure to have boys, we would have only a limited number of children."

CASSIRER: Frankly, I think there must be a way to do it, a way to see that males stay alive. There may be a way of genetic prediction, or manipulation for the future. It is not manipulation, it is just certain chemicals in the uterus; or a choice of a specific part of the menstrual cycle.

ROZE: I think the pH determines a great deal. It has been suggested that sex can be determined by modifying the pH or something in the intrauterine environment.

CASSIRER: Let us not get involved in this, because it is a subject for another group.

BLOCK: We are discussing obstacles.

ROZE: Should we focus on distinctions between countries and continents? Is this something specific that we are able to consider? For example, national stereotypes also impede the knowledge movement between the countries and continents. So, our list includes self-interest, individual business, et cetera; language difficulties; semantic difficulties; political control, selectivity, et cetera; economic difficulties; technological difficulties; sociopolitical difficulties; national stereotypes, attitudes, and so on. That is one type of set. Then we see difficulties between scientists and the people, the lacks or deficiencies. We said, one, there was lack of relevant methods of communicating scientific knowledge, *per se*. And, two, lack of the knowhow—

CASSIRER: I would not say relevant methods only; lack of relevant methods for the communication of relevant knowledge. You mean the relevance is in the knowledge and not in the methods. The knowledge has to be relevant.

ROZE: One, the knowledge of communication of scientific knowledge; two, lack of know-how to communicate knowledge, which is probably method also; three, lack of response to people who know—scientists; four, ivory-tower attitude, which is that science is limited. One is that the people do not respond to scientists, and two is that the scientists do not respond to people. So, four, ivory-tower attitudes; scientists' limited attitudes toward communication of knowledge.

CASSIRER: We listed something much earlier, which is the lack of access to channels of knowledge. The trouble may be in education, it may be in communication. This is a very practical thing. If you have no access to channels of knowledge, then however good your methods are—

ROZE: You know, I have my doubts about that. If the people have the know-how, or if they have the methods of providing that know-how to give the knowledge, the knowledge is there, the books are there. It is not a question of their not being there. Their inaccessibility somehow suggests that they are hidden away, locked away. I don't believe that. I think they are not really locked in, but the locking-in process has been created by the semantic difficulties, by the esotericity of the scientific terminology.

BLOCK: I would say that you are talking about cultural factors. But before them there are a few factors that Dr. Cassirer cited—political, economic, and technical reasons why people are kept from knowledge. So perhaps we could start with this concept of egotism and then we could note certain more or less very technical and economic factors, and then the cultural factors, under which is subsumed language.

So, we would have three major headings: The first would be the egotism, the self-interest, of those processing knowledge. The second would be political, organizational, economic, and technological barriers between those who possess knowledge and those who also should possess it. And finally we have cultural barriers of all different kinds.

ROZE: Wouldn't you say that the political, economic, and technical factors should go under the sociopolitical and sociocultural ones?

KOGBETLIANTZ: The political ones, yes, but not organizational, economic, and technical ones. In some situations, for instance, the Shah of Persia, who is a very enlightened person, would like to have far more communication, but he can't pay for it, and there are not even technological means for doing it in his country. So it is something that could be done if funds were available.

BAUGNIET: On the question of egotism, I think we must also take into account group egotism—national, international, and economic and social.

BLOCK: And, even on the part of the ruling classes of the country who don't feel like disseminating their knowledge.

CASSIRER: Very true; there is an enormous obstacle to the dissemination of knowledge on the part of those who have knowledge because they are afraid if they did disseminate it, it would be used against them.

ROZE: The British colonial policies.

BLOCK: The Catholic Church in South America.

CASSIRER: Basically, there is the social obstacle to dissemination of knowledge because if you have landlords, as in Latin America, and poor peasants, what interest do the landlords have in making the poor peasants informed? They have none; on the contrary, it is in their best interest to keep them in ignorance. All they want is cheap labor. So, therefore, they will not communicate with them. It is not just a question between developed and developing countries; it is a question within the developing countries: often those in control have no interest in disseminating knowledge, and therefore they don't set up the channels for disseminating it. And it must be knowledge that is usable. Knowledge that is not usable and that does not lead people to make use of it and to develop themselves is sterile for them. The important element in disseminating knowledge is the ability of people to apply it. We know that in schools, if you merely tell children something, they will learn much less than if you tell them something they can then apply in experiments and games and use it and give it back to you.

So, the active role of knowledge, the active learning process, the dangers of the active learning process in the social context are one of the great obstacles to the dissemination of knowledge. The transfer of knowledge between developed and developing countries is, above all, an economic problem. In the latter they can't read the books because they don't have the foreign exchange to get them.

ROZE: That is the economic factor, and it is a very real one.

CASSIRER: It is a very real one, indeed. Now, if we have finished listing obstacles, what do we propose as a way to overcome them? My personal reaction is that there are three things. One, we must have a certain technological infrastructure for the dissemination of knowledge, and for the dissemination of knowledge in two ways. Therefore, we need a technological infrastructure to disseminate not only from certain centers of knowledge to other centers of knowledge and to people but also back into the centers of knowledge, so that we can judge its relevance, and also have the confrontation with the identification of people who are in this knowledge process.

Second, you need an educational system that emphasizes the ability of people to acquire knowledge at all times of their lives, in lifelong education from preschool on up, and to acquire this knowledge so that it has relevance to their lives, so that it is not related to examinations or standards that are outside of the objectives of the country but emanate from the real needs of the country. For instance, I was recently in Singapore. There is an emphasis on technological education there, as in the Soviet Union and elsewhere. People work and learn at the same time; not only are they productive and creative, but also they learn that knowledge has a meaning for work and work has a meaning for knowledge, and therefore there is a possibility of doing this at all stages of life. Life is not bound into a period of learning and a period of doing.

Third is a concept of communication as a public utility that must be free to express a multitude of points of view and approaches, and to convey information, not only of a rational but of an emotional nature, that contributes to the growth of man instead of making man more stupid.

These proposals have practical implications. They have implications for the structure of education, for the structure of the community, for the structure of the university, and so on.

ROZE: I don't know what you mean by infrastructure.

CASSIRER: I mean the facilities that exist.

ROZE: The communication facilities?

KOGBETLIANTZ: He means, for instance, having radio receivers.

CASSIRER: For radio receivers you don't need this, but for television receivers you do. Even if you have need for radio signals, there are large parts of Asia and Latin America where you can't get any radio. But you also need the facilities, for instance, for two-way communication for scientists from Colombia to New York. The man in Colombia who wants to do scientific research in Harvard, in London, or wherever. So this is a question of infrastructure; he should be able to take part in dialogue, in confrontation via the media, by satellite or by recorded information.

BAUGNIET: Even within one country.

CASSIRER: Yes. Here in the United States there are linkings between universities. But this infrastructure does not exist; it is very expensive. The question is, is it essential? It seems to me to be essential not only from a knowledge point of view but from the point of view of international cooperation. When you talk about the infrastructure, it means technological infrastructure and the capacity of people to have access to it, not just listening or hearing, but having the education so they can absorb it. We are very involved in the question of book distribution and book publication. Where are books published? They are published in some countries and not in others or, if published in others, not published in editions that are accessible. The lack of publications is an obstacle to knowledge in these countries. The book revolution in paperback and so on has not really made an impact on the access of people to knowledge.

ROZE: Just as an aside, this reminds me of McLuhan's notion that when the mass media impact becomes more and more intensive, books will be of less and less importance and larger areas of public knowledge will be acquired by the spoken word through television. The book will not be wiped out, of course, but the importance we give to book knowledge will gradually go down.

CASSIRER: He allows only the possibility of the ear, and all the information is very rapidly given. But the book is there to memorize and to control and to remain available.

REISMAN: Somebody suggested that what we are dealing with is the means of storage of knowledge, and up to this point—

CASSIRER: It is not only storage.

REISMAN: This has other consequences. We might consider the whole range in terms of the aggregate social consequences. What we want to do is get a sense of aggregate effects of any choice.

CASSIRER: I think the essential things are the multiplicity of channels. There is no one channel that takes the place of another, and the multiplicity of channels has two dimensions. On the one hand, there are different types of channels—audio channels, listening channels, print channels. On the other hand there are other communications. There are channels that address them-

selves to vast audiences; there are channels that address themselves to limited audiences; there are channels that address themselves to the individual. The capacity of the individual to have access to this multiplicity of media is essential. We used to have access only to interpersonal communication. Then we had access to printed communication: now we have access to visual communication and to the computer. Books, of course, have enormous importance. You can reread them, you can study them in depth, you can do things with them that you can never do with radio; and you can do things with radio that you can never do with books.

BLOCK: Consider a young teacher who has a radio set; he also has to consult his books in order to remind him—

ROZE: I agree that that is not the question. But let us see what we can do to overcome these barriers. Now what would be our suggestions?

BLOCK: We have listed a few. I would also say that the question of egotism does not affect the "jet" countries. For instance, they say in Japan now that industry no longer tries to keep secrets; if a secret is six months old it is no longer any good because technology is developing so rapidly; so they disseminate their knowledge very quickly.

CASSIRER: The way to overcome the "secrets complex" is to focus on objectives that are of concern to more than one person or one organization or one country. If you focus on the environment, for example, or if you focus on agriculture, or on health, or on atomic energy, then it makes no sense to keep secrets. The problem of our organizational knowledge is that it is discipline-organized and not problem-organized. And as long as we are discipline-organized, each discipline will keep its knowledge to itself. But if the discipline advances in relation to certain basic tasks of men, then it has every interest to divulge knowledge because it not only will give away but will acquire. So, I think we need a new structuring of the environment, of the academic world, of the government institutions, and of industrial activities oriented toward basic problems of man rather than oriented toward the specialization either of knowledge or of production.

ROZE: Would you say "man-centered" is the essential emphasis?

CASSIRER: Man-problem-centered is more like it.

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BERGMANN: The present public disenchantment with science and technology is largely based on ignorance of the nature of the process of development. No technical process can be designed yet without faults; sometimes the faults can be foreseen, sometimes the faults will become visible only in the course of utilizing the process. The main difficulties we are witnessing today, which have led especially to the pollution of our environment, are based on the fact that rapid solutions had to be found for urgent problems, although it is in the nature of science that we need considerable periods of time to arrive at solutions and time to examine their utility and disadvantages.

An example is the use of DDT, which was essential during World War II and afterward for the eradication of malaria. Nobody had been able to determine in the very beginning whether the byproducts of the utilization of DDT—for instance, the killing of fish and other animals and the contamination of milk—would be so disadvantageous that it would have been better not to use DDT.

It is, therefore, obvious that one of the main objectives of research in the near future must be the examination of the processes and products on which our present technology is based and to determine whether the disadvantages are necessary and whether they can be neglected because of the advantages pertaining to these processes and products.

It is therefore suggested to establish national and, as far as necessary, international research projects and research centers that can advise nations and individuals on the course to be taken in a given situation in which it is necessary to apply a known or a new technology. These centers would deal with the elaboration of methods to overcome the present disadvantages of modern technology, especially in regard to the pollution of our environment.

In general, it should be emphasized that the only way of overcoming the difficulties that have arisen is additional research, and not only applied research, but also fundamental research. To give only one example, it will in the end become necessary to design completely new methods for insect control that, if possible, will avoid the use of chemical insecticides.

Another aspect of the same problem is the dissemination of knowledge required to protect the population against the undesirable byproducts of modern technology. This would be rendered possible by making the information available to uneducated layers of the population in a form that can be understood. For this purpose the mass communications media can play a much more useful role than they have in the past.

There are perhaps two things that have not been emphasized. One is the question of whether the development in or the progress of developing countries should be considered in the same framework as that of the more highly developed and sophisticated countries. We can design new methods in which we will not make the mistakes that existing technology has made in the developed countries. The other question is whether there is any difference between the social sciences and the physical sciences, whether we should not consider something that will emphasize the role of the social sciences in our general project and program.

GOITEIN: I think the first point should be considered, but I would leave the rest to one of the other groups.

BERGMANN: You think we should not include the social sciences?

GOITEIN: When we come to the final problem.

MORAIN: I think we should include them.

BERGMANN: We can question whether there is any difference in the consideration of the program of the planning for the developing countries or not, and, secondly, if we should emphasize all the social sciences in addition to the technological sciences.

I have been asked to go over a list of questions and see whether there is any question we might want to answer within the framework of our subject, which is the humanization of technology.

GOITEIN: Shouldn't we consider the use of these technologies? I mean, for example, the way that television is being used is undesirable.

BERGMANN: Is there anything else that you think we should discuss? This is only one aspect among many. But I thought humanization of technology is something we would want to talk about.

WELLESLEY-WESLEY: Perhaps we should point to a basic difference in attitude between the social sciences and the physical sciences. In the social

sciences one is particularly concerned with the *modus vivendi*, whereas in technology the power framework of mind succeeds in eliminating the other if desirable. They are essentially concerned with values.

BERGMANN: But if our subject is simply humanization of technology, the subject is limited and is outside the fields of social sciences. I think we should mention it when we make our draft, there should be something about the social sciences, although I don't think we have to elaborate on it.

MORAIN: I believe we should include the social sciences, as well as the technical sciences. To whom are we addressing our statement? Probably to other organizations, really. But the goal is to encourage and to keep the vision before people that science is rather broad, rather social. It is missing technical knowledge that gets so many people uptight today; it is all the more necessary to make clear that science is ongoing, self-reforming, and that it is not just the technical sciences.

BERGMANN: Perhaps we can go over the list of questions provided by the organizers of the conference and consider them point by point to determine if they are relevant to our mandate. The first point is, "What would be the long-range and immediate goals of a worldwide system for the transfer of information? How can we safeguard the humanism of such a system, insuring the realization of individual dignity?" I don't think that belongs to our point. The second is, "What are the ways in which present technology can be applied to such a system? What sort of technology might be important in the future?"

GOITEIN: My answer is: I don't know.

BERGMANN: Before one has an answer to the first question, it is difficult to say what technologies one can use in order to make this workable. So I don't think we can say anything about it before we know.

Three: "What steps should be taken to assure the continuity of a lifelong educational system in the eyes of the individual? Are there optimal ages for any parts of the educational process?" This bears on our earlier discussion. I think we can agree that one of the most important things in the whole problem of humanization of technology is the dissemination of information to nonscientists in such ways that it can be understood. This means, of course, that we will have to use extremely popular language in order to explain what we want. But it does not mean that in the future we may not find better methods of education. Many people now think much more seriously about postuniversity education; people who have already finished the university should return to it; the process of learning, academic learning, should not be limited to reaching the Ph.D. but should continue for life.

REISMAN: I think the word "learning" is better than "education." We should break with the notion that one can learn only in an institution. In a changing world, we have to understand other ways of life.

WELLESLEY-WESLEY: It is less ambivalent. I can certainly think of other types of education.

REISMAN: It has a certain noninstitutional flavor, which is obviously important since we can't have people going to school for the rest of their lives.

BERGMANN: We have said that we think the mass media can use their facilities much better than they are being used now for the dissemination of information that is necessary for the fight against pollution. And I think we might add that continuous education is a more reasonable method of education, even of adult education. And then perhaps you are right, we should

not use the word "education," because we don't mean education in an institution, but "learning."

MORAIN: Another aspect is that there is a trend now for some people to confuse the symbols with what they represent. For instance, you get your degrees much as one might get union cards or certain identification. In certain schools in the United States, there are students admitted who have not met the traditional requirements for entering college. We have some eighth-or tenth-grade performance-level students who are now freshmen in college, frequently from minority groups. Some of these individuals and some of the people in the academic community may feel that they have to get into the college framework so they can get their degrees because they are necessary.

But it is interesting that some of the individuals involved associate being in college with the achievement itself, and they are not too worried about the learning. So education has been identified as college and degrees. But some who have not felt that they are a part of that process want to get the degrees and the education without having to go through the hard work entailed.

GOITEIN: Just a status symbol.

MORAIN: Yes. This is a new aspect.

REISMAN: I am not so sure it is a new aspect. From a sociological perspective, and from an economic standpoint, everything has a value as a commodity; from a sociological standpoint everything has a certain status value, and in a certain sense identification with the university has been one technique for acquiring status.

BERGMANN: In a university in Europe, where you became a member of the intelligentsia, it gave you a certain life style for life. This, again, has nothing to do with learning. Yes, I think we should eliminate "education" and put in "learning."

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WELLESLEY-WESLEY: I think making technology better understood by the general population is a very difficult task indeed, because the ordinary person is not able to understand the technical language that has been developed by the various disciplines. As to the fear and anxiety that technology may be creating in him, I think this very much depends on linking technology with his own basic needs; and it seems to center on whether the technology and the application of technology is seen by the ordinary person to be in his interest.

MORAIN: On the point about the humanization of technology, did that mean to exclude science other than technological sciences? I repeat this, because most people are willing to say scientific information is fine in technology but are worried about its misuse. But there are also the human sciences, psychiatry, sociology, and anthropology. They are supposedly concerned with people. But you can find one anthropologist referring to another as unscientific. You see social scientists not even able to talk to each other. Two chemists can talk to each other, they have an objective language, objective symbol system. But you can get two psychologists who don't even use the same lingo. This somehow needs resolving, perhaps an admission that just because something is scientific, it may not be complete, whole. Just because something is done scientifically, prepared scientifically by someone calling himself a scientist, does not mean that it automatically is all-encompassing. The population is troubled on that.

GOITEIN: I don't want to bring in any more red herrings, but this problem has arisen in England. The general public can't distinguish between science fiction and science fact, between flying saucers and the real things about Apollo; and what anybody can do about that, I don't know. But there is a great deal of distrust of science because of that confusion.

BERGMANN: I think that this is the point at which we should make clear that it is necessary to have better information for, or better education of, the noneducated public.

GOITEIN: But that is a very long-term project.

REISMAN: The whole focus here is on long-term vision, so we should not be deterred that this may take 50 or 100 years.

GOITEIN: Frankly, I think it is too big a problem for us to discuss, how to dissipate all this magical thinking about science.

BERGMANN: We should be content with saying it must be done. How it can be done, I don't think we can decide. In any case, I don't think it belongs to the realm of such a conference, to detail how it should be done. There should be experts.

MORAIN: You have said several times that you doubt whether it belongs, but I wonder if this is so. I think discussing only technology limits us too much. For instance, if we abide by the technology limits, we are almost excluded from talking about science among our young people. One of the necessary things to do is to dispel some of the old notions and to be supportive of methods that try to advance science as a living process. Just in terms of the humanization of scientific technology, there is not very much one can say about it. It is all sayable in a few sentences. That is hardly a basis for discussion.

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LANDAU: I think educators today try to educate on convergent thinking, and what I would like to imply is divergent thinking.

PORTER: Isn't that involved when we discuss potentiality?

MARSCHAK: The fact that it is a big jump may not make it divergent. You can make a lot of quantum jumps. It is a question of which language you want to use, whether you want a language of physics for that particular concept, or you can use divergency—

LANDAU: Instead of divergent, could I say multisolutional?

BRANDT: Divergence means not only connected with solutions; you don't always think in terms of solutions.

MARSCHAK: Dimension is a very good concept.

LANDAU: But that might be only a result.

PORTER: Convergent thinking is sometimes useful.

MARSCHAK: Would the phrase "many-faceted" help? If you use a term like divergent, it means different things to different people.

BRANDT: Multisystem, maybe, a system that fools you into thinking that divergent can be transferred into convergent.

PORTER: Yes. A mapping process. That is the trick, isn't it?

BRANDT: But the name may fool you into certain beliefs that are not quite realistic.

PORTER: But we are talking about the difference between induction and deduction, really.

LANDAU: Perfectly right. But some wonderful results come out of unrealistic thinking. This is playing with elementary ideas.

BRANDT: But the trap you may fall into by multidimensional project is to try to make things convergent when they are not necessarily so.

LANDAU: I would like to consider another aspect, that of communication. To inquire in spirit is academic. But also we must think about the religious aspect because religion is being afraid of the unknown. I would like to say something about what I do with the child. I allow him to do something with his design, but I also ask him what it is so he can communicate. And this is very important, communication for intraspace and interpersonal communications, to make it clear to himself and to make it clear to others.

PORTER: This is the whole problem of the teacher.

BRANDT: These generalities are not in fact applicable to just any situation, and they were as valid 5,000 years ago as they are now. But the situation in the world now is that there is a much more intensive education between all the cultures, all the faiths. This is just the educational process, And if we include in that all the mass communications, there is an enormous set of instruments that function to bring about communication between these cultures, and help develop certain groups in relationship with their own culture and their relationships to other peoples of the world. This could be seen as an instrument or a tool, if indeed you can find anyone, or any group, or several groups that use this more or less consciously. In other words, is there a strategy? I think this may be one of our main points: it is educational strategy that will in one or another way help the world develop. "The world," of course, is a vague term, but it will help in this whole process of development and of coming to a real understanding between different groups.

LANDAU: Isn't that saying "hospitality?"

BRANDT: We have to be more technical about it because we have to deal in this situation with a number of different cultures, with a number of different institutions, with a number of different political systems that have limitations. All this exists presently, and you can't simply discard it. You can, according to this pattern, build up an idea of a society as it should be, although you don't have it now; you have to see the limitations.

PORTER: I think, if I can use a McLuhanistic expression, that this is recognition of the characteristic sensory profiles of the cultures that are being changed by the communications media. In other words, the tactile, the visual, the auditory, and so on; this is now being changed, and it must be recognized in any of our discussions. Our trouble is that we are trying to thrust a visual culture onto one that is essentially an auditory and tactile culture.

MARSCHAK: These are different philosophical approaches to the problem, but could one come up with the recognition of a universality of cultures that now exists in the world and a specific strategy to overcome the differences, and so on. So I ask: Are you talking about a world university that is looking into global problems in a defined sense, or are you talking about developing, as you say, a strategy of education? I think what Dr. Brandt has said is very interesting and is certainly part of the picture. But to be more specific, I have been interested in the international university, and we have developed some proposals for a world university. Just to give you an idea, we were considering justifications for creating a world university. For instance, a world university would be of great value in disseminating human knowledge for the purpose of

solving global problems, taking into account national, racial, and political differences.

LANDAU: That is another group. This is the categories of knowledge to and from developing areas. Would your world university manifest a special character in three essential respects?

BRANDT: I think not. I was not actually thinking of a world university. I was thinking rather in terms of how you can develop such a strategy, and the strategy for developing a strategy—because you can't merely sit with a group like this, and with a few other groups, and try to set up something.

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ROZE: To begin the discussion about the results of our group, this is a brief summary, actually, of what the subgroup on communications discussed. It is by no means conclusive. An essential aspect in exploring the changing image of man and his understanding of nature and the universe is that knowledge, experience, communication, continuity in the world society, the individual and sociocultural transmission and exchange of knowledge, is conceived as an important process integral with all other functional societal aspects leading toward the conceptual and existential integration of human diversity (psychological, educational, social, national, sociocultural, et cetera) and the advancement of human society. For the dissemination and exchange of knowledge, the following obstacles have been identified as hampering a free flow of communication on local, national, and international levels:

One. General impediments, such as:

(a) Self-interest or created self-interests (on individual, business, industrial, technological, et cetera, levels).
(b) Language barriers.
(c) Semantic and specialization barriers.
(d) Political and governmental control and selectivity.
(e) Economic obstacles.
(f) Technological difficulties.
(g) Sociopolitical conditions.
(h) Rigidity of national stereotypes, attitudes, et cetera.
(i) Limitation of religious belief systems and ethical mores.

Two. Scientific versus public communication difficulties:

(a) Lack of know-how to communicate knowledge by scientists and scholars (impenetrability of certain scientific facts).
(c) Lack of response and lack of feedback between scientists, scholars, and general public, and sensitivity of policy-making bodies.
(d) Ivory-tower attitudes of scientists and reluctance to communicate knowledge.
(e) Lack of access to knowledge.

And, based approximately on the group's discussion, I briefly wrote out the following proposals:

1. Establish a central coordinating transnational and interpolitical center for study and evaluation of present use, impact, and future possibilities of the communication process in the world society, with special attention to (a) releasing the communication process from present obstacles and constraints; (b) actualizing the communication network as a means of all-inclusive exchange and interaction among individuals, groups, societies, and nations; (c) optimizing of the general process of knowledge-experience dissemination, with a view of humanization of technology and integration of man's undertanding of himself and his universe.

2. Urge the establishment on national levels of "communications research and application units" geared to an optimum dissemination and use of technology, human resources, knowledge, and experience with the release of constraints on the communication systems.

3. Establish a man-centered, life-problem-oriented, multidisciplinary international knowledge bank geared toward the optimization of the quality of life on our planet and enhancement of human excellence.

BERGMANN: I will attempt to summarize the points our group tried to make. First of all, we said that the present disenchantment with science, and especially with technology, is only to some extent due to the misuse of technology, but mostly to ignorance. The problems have arisen from two sources: one, it was necessary to find quick answers to urgent problems, while it is in the nature of science that answers take time, and the longer they take, the better they are, the less they will be accompanied by difficulty of experience; and, two, industry has so grown that problems of by products that, when industry was small were not visible, have become visible but were not recognized in time.

We gave as an example DDT, because it was made for an urgent need: the fight against malaria. At that time, anybody who would have said we would have bad side effects would have been laughed at because the importance of fighting malaria was so great.

There are many such problems that are not new but have grown immensely. Therefore, it will be important to restudy all those forces and products that our present technology is based on in order to best avoid ensuing difficulties similar to those we are now witnessing. It should be clear that this means that all our industrial products will be more expensive than they have been until now. There is no alternative to that but giving up industry. It will be essential to establish centralized national and international projects and programs to correct the sense of technology and to undo what has been done by neglect and to advise nations, groups, and individuals in a given situation on known or new processes or products about to be introduced.

We think, then, it should be pointed out that the only way of overcoming the present difficulties will be additional research, and not only research on products and processes themselves, but also fundamental research, without which we cannot solve the problems facing us.

Finally, we think that another aspect of the same problem is that it will be necessary to create a much better method of dissemination of knowledge to noneducated people. We also believe that the mass media can be put to much better use in this respect. The long-term way to overcome difficulties would be if we could make education a continuing process throughout life, so that people will be able to understand and to accumulate the knowledge that is necessary to live in today's world. It is perhaps necessary to add two minor points to our final draft, and they are the possible necessity of emphasizing

the differences in strategy for developing countries, which is not necessarily the strategy that has been used in the developed countries, and a comment about the different position of the social sciences from that of the physical sciences.

LANDAU: We spoke about teaching institutions, educational institutions, both on the national level and on the international level. We tried to consider details, not only for a world university, but those that could be applied to each stage of the learning process. Institutionally, learning and education should be planned for all ages, beginning with kindergarten, going through the schools, and should include the reeducation of persons who seem lost to us but who still can be educated. That includes teachers who still teach in the old, conservative ways.

DEWEY: We started with acceptance of the general idea for a new institution, or some present institution, that would be really modeled to do these things, although we did not work in any great detail. Our statement notes the need to "invest the experience and knowledge of yesterday with the stimulation of today, with the vision of tomorrow in such a way as to develop a creative attitude toward knowledge and experience, not the mere accumulation of facts."

"To achieve these goals, we include all aspects of personality in the educational process not only as it has been until now, the academic *homo sapiens*, but also—"

This is in your writing. Do you want to read it?

LANDAU: Until now we have called it academic, but because it includes the psychology of thinking and all other aspects of the human mind—the toolmaking, the political and religious aspects of personality—we state that responsibility should be also taught and developed so that learning can be used for constructive purposes.

"Goals that are developing for academic, creative, planning, forecasting, decision-making, and communicative aspects of the human personality, with the assumption that the personality is never only one-side-talented but is multitalented. No human being has only brains or can play with only two things, but he is multitalented, and we should use those aspects of human personality."

DEWEY: "These are the specific ways to appeal to these different aspects: One —" and then you have seven points there.

LANDAU: To effect the curiosity experience, the questioning, which is a human potential and should be fostered and treasured during all of life.

Foster divergence, not only convergent thinking.

Foster ideas that encourage the emergence of new ideas, which is a neglected area for adults as well as for adolescents, when play and serious work are put at poles, one versus the other.

Develop self-confidence in imagination, intuition, and ideas; not dependence on authority in books, but let them develop their own intuition.

Hospitality toward new ideas, one's own or others', which implies humility and deferred judgment.

Exploit the full potentiality within any given framework that does not exclude the jumps into completely new ideas.

Each human being should be taught from an early age never to feel there is no alternative. He should be encouraged to rupture the framework of the frontier.

All these points should be fostered in such a way that there will be meetings among scholars or pupils where interdisciplinary discussions will take place.

Intra- and interpersonal communications training should be fostered because it is very important for the human being to be in communication with himself, to know himself in order to know the society and accept the society and be accepted by the society.

BLOCK: To improve the examination of knowledge leading presumably to increased quality of opportunities for men and women of all classes, races, and nationalities, we feel three types of obstacles are to be overcome. The first type involves the feeling that knowledge is property and that individuals of privileged classes of particular countries or civilization can be allowed to keep information from the rest of humanity, or by dictators and others to keep the people from getting information. The second type involves limitations due to lack of funds or technical installations, conditions, and lack of logical development or organization. The third cycle of difficulties has to do with language, lack of understanding between individuals and peoples.

In order to overcome such difficult obstacles, we propose that technologically improved intercommunications be promoted both within the academic community itself and between that community and the people as a whole, and that funds must be provided; communications satellites operated by, for instance, UNESCO, might be an integral part.

Second, that a center for teaching methods and the production of educational materials be established, again perhaps by UNESCO, to provide material for various countries under the supervision of experts with a thorough knowledge of the social contexts; that the concept of education as a public utility be implemented—that a multitude of views be expressed of both a rational and an emotional nature to promote the growth of man; that research be more geared to the larger problems of mankind; that more efforts be devoted to the identification of problems felt to have relevance for the life of individuals and groups in all parts of society and of the world.

* * *

BERGMANN: In the Working Group's final statement, we should be much more specific about the dissemination of knowledge. I think we should refer to the possibility of insisting on having the most modern methods of collecting information in the form of microspots, which would make it possible to get all the information that exists in words into a very small physical area; this can then be relayed by satellite or any other means, even telephone.

I also think we have not emphasized sufficiently the problem of language. And we should refer to the possibility of translating machines, or translating computers, so we could have the possibility of automatically translating from one language to another. This is undoubtedly a development that will take some time, but it has been proved feasible; it is very important because the language question will always present difficulties. This is especially true with regard to the possibility of international educational institutions. It is not really a reasonable proposition, because of language problems. We should at least consider the alternative for the international or central institution that would work out methods of education in various fields. You cannot absorb education if it is not in your language. I think we should at least mention as an alternative, instead of having an educational institution, the creation of an international institution for preparing educational material, especially curricula in the various sciences.

LANDAU: In this connection, I would like to raise the question of an

international language; it would be a language of the country, the baby talk, the language of love, of poetry, but it would be also an international language that would be taught in the schools, and science would be taught in this language. Perhaps we could somehow bring up this problem, even if it does not succeed.

BRANDT: One point that has been much considered is quite relevant in the field of education and coeducation in college, and that is decision making. In the world today, a relatively small number of people are very actively engaged in this, although many others more remotely. In this process, education plays an enormous role, and I bring up the point because I feel it should be discussed further.

BLASER: It has been mentioned in one of the advance papers, which noted that through further education and dissemination of information the decision-making process will be expanded by necessity; this has always been the evolution.

BRANDT: I think that is too vague.

LANDAU: There is a Working Group dealing with decision processes. Of course, decision making is one aspect of human personality, but we were afraid to enter into too much detail. I think there is no reason to refrain from such discussion, however, because it has to do with fragmentation.

BLASER: There are certain limits that have to be set because there is always a dichotomy, on the one hand of fragmentation, and on the other hand of overlapping; we have a limited amount of time; the scarcest resource that we have is the time that we are spending together, and we are hoping to get the most significant amount of work done.

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MEAD: Dr. Cassirer, perhaps you will summarize yesterday's discussion so we will have it on the record and I will understand where I was.

CASSIRER: I am not the rapporteur, and it is really Michael Reisman who should be doing this. But I think he is very busy on the report, so I will try. First of all, our groups approached the question in three basic stages. One was overall objectives. Second, we looked at 1990, and some of the conditions we expect in 1990, with an indication of the human condition and values to be aimed at. Third, the three subgroups met and put forth first drafts of some ideas. One commission dealt with the humanization of technology, another with education, and the third with the dissemination of knowledge.

This is an open-ended situation; if we don't have solutions, we don't know where we are going; we don't mind if the papers are contradictory or there are things that aren't fully integrated into a complete plan. We are not trying to be so neat that everything is nicely written and fits together when in fact it doesn't fit together. On the other hand, there was also a feeling that, in fact, there is a good deal of overlapping between the basic ideas of different groups, that there is this feeling of a certain prospective notion, let us say, in 1990. How do we get there? The feeling is that the systematic approach is not able to get things done in a piecemeal way; there is not enough to show immediate action.

MEAD: I think this Conference really wants a kind of mandate for taking the necessary steps. Because, after all, we are not going to make a final

statement, but we could say something that might give direction to either the World Academy or the World University.

I think the concept of the World University is quite relevant to the form that our discussion takes. Because there are discussions going on, for instance, in this country by The New York Academy of Sciences and its Committee on Science and Public Policy, of which Harold Lasswell is chairman, and discussions with the National Academy of Sciences about the possibility of some monitoring, assessing organ.

One of the things that we might be in a position to say is whether such a central group of softwear—that is, of human intelligence that we are temporarily substituting for those computers that are not yet here—should be worldwide from the very start, or whether we should go through a phase of national groups and efforts, for which we possibly don't have time.

LANDAU: It should be in the wider, international sense. We could use this general international approach and enter into it the local means and needs.

BAUGNIET: It is necessary to enlarge the participation and to have many participants from all parts of the world, with no exceptions, even China, if possible.

MEAD: Quite.

PORTER: Do you know, Dr. Mead, if there has been any dialogue or any talks between say, The New York Academy of Sciences and the National Academy of Sciences of the United States and the Royal Society, Britain, the Academy in Sweden, et cetera?

MEAD: They have been carried so far by an overlap of persons. Dr. Lasswell has been working closely with the idea of the World University, and Dr. Lasswell and Dr. Pregel and I were all at the Stockholm conference and we were all on the committee of The New York Academy of Sciences. We are talking about such possibilities. And this Conference looked like the the place where some of the strategy might be worked out.

We are not thinking about an attitude here. We are thinking about a group of identified persons, bodies, who would have the capacities that Heinz von Foerster has discussed, the capacity to integrate, by the use of their own heads, a sufficiently world view so that we would have one approach, because there is no possibility of dealing with the environment unless we have a unitary approach. Otherwise, the food people will be increasing food and increasing population while the population people are trying to decrease it, which is what is happening everywhere at present. One group of people will be worrying about the effect of pesticides and the exportation of pollution, while FAO is announcing that fertilizer manufacture is going to go up and up and up and, in effect, save the world.

If you take the reports of the international agencies at present, they conflict with each other at a great many points: each has a valid argument, but they must be put together. And, to date, of course, environment and population have been kept pretty separate.

BERGMANN: Yesterday, reference was made to the International Council of Scientific Unions. As far as natural science or physical science is concerned, the ICSU as a group is composed of representatives of the various disciplines and is expected to work collectively, but it doesn't really do that. Essentially, it deals with organizational questions. But I think one could recommend that

the emphasis be much less on the organization of international science and more on instilling and developing ideas about what to do.

This year, for the first time, an effort has been made in the field of pollution by transforming the International Biological Program into something that would emphasize man's relationship with environment. And this not only would be in the biological sciences but would be an attempt to do this as an overall program.

As I said, on the whole, this might be a body of the type we would like to have, but it doesn't yet fulfill the task we believe is essential.

MEAD: And it has, of course, from our standpoint, the drawback that it includes only the members of the United Nations and does not include the entire planet at the moment. They don't have a chance of dealing with China, do they?

BERGMANN: As far as I know, there is no connection with China. But they can establish one. In the institution there is nothing that links it to membership in the United Nations.

CASSIRER: I would like to make a basic point. Organizations supported by UNESCO, not being governmental, are perfectly free to choose their members. For example, we support financially quite a number of organizations with members in East Germany. East Germany is not a member of UNESCO, but this is not a matter of our concern. Our goal is to promote international cooperation in particular professional fields. And it is for them to decide their composition. The only thing we require is that they be international, in the true sense. We will not accept an organization that has just a few countries. This gathering is, from that point of view, not very representative.

MEAD: You require internationalization sometimes to the point of extreme difficulty, if you are looking for a particular kind of scientist.

CASSIRER: One of the reasons we do it is because he may not exist at the moment, but, then, he ought to be trained.

REISMAN: Since we are looking to the future and broad goals, our organization might be described as one in which maximum inclusion is transcending transient political division.

MEAD: Would you repeat that?

REISMAN: The suggestion I made to resolve this difference—and I don't think there is a real difference here—is that we state that the entity toward which we are working is one whose membership transcends national boundaries; this formulation is sufficiently flexible for a certain degree of independence for politics.

MEAD: I think we probably would have to add that it not only would transcend national and state boundaries but would be worldwide. Otherwise there is a tendency to limit it to those countries that have Westernized scientists.

DEWEY: This organization, like every other, has a financial problem. It seems to me that if we could prepare something that would delineate the needs of the world and show the ability of this organization, through its range and organization, to meet those needs, it would offer an opportunity to raise money that would otherwise be lacking. If I had the job of raising money for this organization, I would take in my hand a dramatic statement of the needs of the world and the specific ways in which this organization chose or planned to meet those needs, and some proof that we could do it, and ask for $5 million. You need a prospectus.

MEAD: We need a prospectus in terms of what can be contributed by research and integration of research, and not statements that it will cost $60 million to restore Lake Erie to its state of 25 years ago. So much discussion in this field has been stymied by those fantastic monetary statements. We must deal with the needs of the world in terms of what we are going to do with Lake Baikal or Lake Erie with our present state of knowledge and technology as against the need of the world for research, so we won't have to spend $60 million on Lake Erie.

DEWEY: What is proposed here is an organization, perhaps misnamed World University, an organization that can contribute to the solution of these great problems in a major way, with a relatively small amount of money, by stimulating others and integrating the activities of other people and other groups that are already financed. In that way, we might accomplish something worthwhile; if we hew to that line, I think we might help the organization more than we could in any other way, and help the world through the organization.

MEAD: Do you think that we should combine this with our target date of 1990, or —

DEWEY: I would think of the immediate needs of the world.

BLASER: Just as mentioning huge monetary sums will stifle development, setting goals too far in the future makes them much less tangible. If we set the goals for a more immediate time, then perhaps more immediate support could be realized.

CASSIRER: I think there is a misunderstanding about this 1990 idea. As I understand it, the 1990 target is simply the development of some concept as to what is likely or not likely to happen, or what is desirable. If we work in terms of the present only from step to step, we really work in terms of the past. And that is not what we want to do.

MEAD: So we say 1990 is a feasible and not-too-distant target, but it's in the future; what we can do today, what needs to be done today—

DEWEY: The goal for 1990, as I see it, is for our own thinking, but not an important part of our presentation to the Conference.

BERGMANN: If we can formulate our problems today to carry out research programs successfully, from the idea to the operational stages in the natural sciences, there is no real conflict between knowing about present problems *and* 1990; it would certainly take until 1990, even if we had the money to solve these problems. If I needed a method, for example, to fight insects without chemicals, it would be a very high rate of progress if I could find it before 1990. Therefore, I think there isn't any real problem in talking about 1990 and our present needs. We do not find the solutions to anything in a short time.

PORTER: I feel that an awareness of what is actually going on *now* is quite important.

MEAD: I am a little worried, Dr. Bergmann, when you say the natural sciences, because it doesn't seem to me it is of any use for the natural scientists to solve the problem of handling insects in this way if they don't take the other sciences into consideration. One of the things we ought to say is that unless we have an across-the-board approach these single, beautiful technical solutions simply create as many problems as they solve, because they don't take the rest into account.

BERGMANN: I agree. I know only the natural sciences, and it takes ten

years to reach a solution. Perhaps in the social sciences and psychology it is quicker.

MEAD: The solutions we get, if announced, then change immediately the state of the world, so that we have to work on another. We don't work on the solutions; we work on the state of the world, on the capacity to use the solutions, which is continuously changing. So, in assessing a group that is working on essential research, you must have an arm that delineates what is going to happen when the results are announced. There are already countries that are going into panic over their population. In the social sciences, you have to begin stopping something the minute you start it, if not a little bit before, or you get yourself into very complicated situations. But you would like to say, in general, that it takes ten years to work out the natural side of one of these major problems?

CASSIRER: I still think there is some confusion. Of course, it can take ten years to create something. But where do we go? If you take education, it takes more than ten years to educate the child. But the question is, what is it that we need to educate the child with? In what kind of frame of mind? What kind of attitude? What kind of content and what dynamics, so that in 1990 there is a difference in society? And this is why the two things are so related. You can't set educational policy today in terms of today.

MEAD: Would you like to start making a list of these needs that you could present to some imaginary organization?

DEWEY: I think all those needs have been expressed during this conference. Suppose I had $500 million and you wanted to get a nice chunk of that for the World Academy of Art and Science. And you started to talk about the World Academy, what it is, a group of the most distinguished men in the world who have the most brains in the world, and this is an idea of bringing these people together. They are all public-spirited men. Bring them together to use their collective wisdom. What are they going to do, what are the problems with this, this, this, and this, and what are they going to do to solve those problems and how are they going to do it? You would have to get me excited to the point where I would like to make a substantial contribution to the project.

I think it would be the sense of this whole group to emphasize the problems that this group knows about, and emphasize the means of solution that this group knows about. We could make a sales presentation to anybody we want. If any of you would take that challenge, to go to somebody who could solve the financial problems, and make him want to solve the financial problems, I think we would have something out of this that would be worthwhile. It is simply a matter of collecting and organizing it.

MEAD: Are you thinking of this under headings like "world population," or headings like "better methods of desalinization" or "insect control?" Do we break it down to that next problem level?

DEWEY: I think it should be kept to the major problems. It isn't a matter of desalinization. It is a matter of getting water. It is a matter of reclaiming deserts, if that is one of the problems. If we need more land, there are various ways of getting it. The problem is, what do the people need?

PORTER: Energy, health, education.

DEWEY: Yes, but it can be made specific and dramatic.

VON FOERSTER: Clearly, we cannot address ourselves to any problem of the present if we don't have a future state of affairs in mind, so that the framework in which these solutions are carried out fits in that future state of affairs. Otherwise, we come to a present-day solution only, which blocks further development that seems, in the larger context, to be a necessary solution. We have seen this before, and now we are sitting here saying, "For heaven's sake, why didn't we do this before?" This is a very general framework. A general framework can be so abstract that it is meaningless; there could be a limit to this if we would address ourselves to the exemplar of a particular program that could be taken not as a particular solution but as an exemplar of how one would approach a particular problem.

MEAD: We could work out this examplar. I would then want to extract it again. There is nothing as dangerous in the United States as an illustration—of anything.

VON FOERSTER: That's right.

GOITEIN: May I suggest that we recommend communication in the underdeveloped countries to enable them to take advantage of the Green Revolution?

MEAD: Wouldn't we extend that to communication including the underdeveloped and overdeveloped? I think it is terribly dangerous if that occurs only in the underdeveloped or only in the overdeveloped countries. We have to include both.

BLASER: Perhaps we could set up a model for a system of pooling worldwide resources—worldwide computer linkups, worldwide telephones, worldwide flying seminars, worldwide television. These are the means of fast communication that especially serve the developing nations as well as nations farther along in their economic and social progress. If we could set up plans for an institution to coordinate this with the help of the governments, including leasing of facilities or granting of facilities, it would be valuable.

VON FOERSTER: This is implementary. The question that goes to the floor is whether we should really do it.

MEAD: It may be wise to take one hardware and one software problem so we wouldn't be accused of inhumanity and forgetting man.

(A short recess was taken at this point, and when the session began again, a portion of it was not recorded. Further segments were omitted because they were concerned solely with the wording of the Group's report.)

BLASER: I would like to suggest that we include in our document a short monograph on the place of the social sciences as a mediator between the basic sciences, the natural sciences —

MEAD: And the humanities.

BLASER: —and the inventory of human needs that we want to establish.

MEAD: We really need four items. As the world is now constituted, we need the natural sciences, the social sciences, the humanities, and the arts, because otherwise the humanities are just about the same as the arts. There is never any art there. And you need all four, and each one mediates among the others.

PORTER: I find that the humanities are more isolated than the natural sciences.

MEAD: They certainly are. It has often been pointed out that there are many natural scientists today with a little, if not an extensive, knowledge of humanities, and no one in the humanities knows any part of science.

CASSIRER: I have a basic reservation, which is that the decision maker must be equipped with a broad frame of reference. A scientist has to have a broad frame of reference also, and that broad frame of reference doesn't come only from the decision maker and the scientist. It comes from the people.

Knowledge of decisions affects man. Dissemination of knowledge is one thing, but knowledge in somebody's head isn't known. We and the others have no knowledge. This doesn't reflect the spirit that I feel we should reflect.

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MEAD: I think we are going to have to get rid of the word "discipline." We tried "interdisciplinary." We tried "transdisciplinary." We invented it, you know, as a way of including the applied sciences, so that a nurse could be allowed to sit down at a table with a physicist, which was inconceivable 25 years ago. But it has never included practitioners of the arts; we don't talk about music as a discipline. Now we need a word that goes all the way from music and painting and philosophy to physics, and it should stop along the way for electronic engineers and for nurses and for people who practice various applied disciplines.

So if we can't invent a word today, we might put in the statement that the use of the words "discipline," "interdisciplinary," "multidisciplinary," affirms by denial the separateness of the disciplines. We need a new word that will incorporate these with virtually every form of specialization, including the capacity to generalize. Put the generalist into this picture also. Maybe we will invent a word. Somebody might have a wonderful idea.

Another general point is that the concept is not "man and his environment." It must be "man *in* his environment." We must get rid of the "and" that has plagued us through history. The unit was originally man, individual man, then groups, then nations. I think it is terribly important to include the environment in each unit. Man *and* his environment ends up with: Is he at peace with or at war with it? Is he going to chew it up or eliminate it? One thing this Conference ought to do is get rid of "man and nature." It is man *in* nature, and it is man *in* his environment.

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KOGBETLIANTZ: In my opinion, development of knowledge is a kind of biological process. It cannot be stopped. And it is accelerating so rapidly that we must think about the future, eliminating the burden it imposes on man. Already, with the discovery of nuclear energy and construction of electronic computers, we have entered a so rapidly changing phase that we all fear it. Suppose that, tomorrow, physicists master fusion. There are awful, wonderful possibilities for using this new, cheap type of energy, but also there is danger. An example of the danger is the nuclear bombs, which are prepared by Russia, America, and France, and Germany is now working on it; all this shows that, if we gain information from the development of knowledge and the development of our knowledge, we must not forget the danger inherent in a too rapid acquisition of knowledge. Maybe we should mention that we expect some regulation of the use of new discoveries in order that they not be harmful for mankind.

MEAD: One of my colleagues has invented a word, an idea, the idea of a macroscope. A macroscope would simplify to essentials any problem and eliminate details. It would have the same function toward the body of knowledge that the diminishing glass has to a painter: it would make it more manageable. I think it is a good idea.

VON FOERSTER: Beautiful.

MEAD: We need something of this sort to continually reduce the mass of detail to its place so that one can look at the whole system.

KOGBETLIANTZ: And, maybe, legally put limits on use in certain cases.

MEAD: Well, you are thinking then of destructiveness. You have really made two points. You have cited the burden of too much knowledge and the possibility of harm.

KOGBETLIANTZ: Control. It is a biological process, and it is important that we not be the victim of this too rapidly developing biological process. It must be controlled.

MEAD: I think there are two different points here. One is that we have to have ways of making this proliferating knowledge manageable. It has to be held in a few heads. It has to be dealt with in some way, which means putting an awful lot of stuff into storage and getting it out only occasionally. This is what a macroscope would be useful for. The other point is destructive knowledge. There I think you are posing a question on which there would be a great deal of disagreement. Would you like to discuss this? Because it is a drastic suggestion.

VON FOERSTER: I think the interesting thing is, if you have regulatory agencies and legal machinery to hold something down, then apparently there is a possibility of acting in a way that is contrary to the law. The fascinating thing to me is that there are all these rules of behavior that are not regulated by legal machinery, but people obey them. It means that people have a regulatory machanism that doesn't allow them to think in these terms.

For example, an overpopulation solution: drop a hydrogen bomb. First of all, I would say that it won't work. That is the technical answer; the other answer is that it is not *considered* as a solution. In many cases a solution of this form is prerejected; it is not taken up. This is the second problem. This is an educational problem. It means that people may have a different perception of man, the globe, and where they live, and the question of abuse of knowledge may crop up. I think one can cite thousands of examples where people act in a particular way without being told.

MEAD: And the minute there is a law, they think of breaking it. Even in councils, everywhere, no one is proposing war, plague, or famine as an answer to the population question. I am perfectly convinced that if, 40 years ago, we were being faced with the state of Asia as it is now, we would say, "Let them fight their own wars, kill themselves off, and the more the merrier." In the seventh century in Ireland the convocation of bishops prayed to God to send a plague to kill off the inferior order of men. There is no bishop in the world who would make that prayer today, and he wouldn't even think about it unless he was very old.

Have we completed the discussion of self-denial, the destructiveness of science? I think that ought to be expanded somewhat, perhaps. Should there be limitation on scientific research or legal limitations on its use?

KOGBETLIANTZ: Limitation of the uses. For example, the old saying, humanitarians should not use such and such kinds of —

MEAD: You see, Dr. von Foerster made the point that the only effective limitation is the development of a climate of opinion that makes an action unthinkable. And that is the only safe way, because legal regulations can always be subverted.

BAUGNEIT: Supranational legal.

MEAD: Even then you awake in some minds immediately a reason to subvert the regulations at once, whereas it is unthinkable to use plague as an answer to the population explosion. This will be more effective than legal limitations

on experimentation with biological warfare. I think that your suggestion would include as an example a legal limitation on experimentation with biological warfare, wouldn't it?

KOGBETLIANTZ: Naturally. It would do so much harm, experimenting with germs.

BERGMANN: I think one tends to say one would like to have a limitation on the use of biological warfare, but one cannot demand limitation on the experimentation for biological warfare.

MEAD: I wonder. If you approve experimentation, which at least in this country and certainly in most other countries means government financing, which the citizen has an ultimate right to control, and if experiments go on, you are producing new disease-producing entities. The prohibition of biological warfare or experimentation won't mean anything unless scientists refuse to do it, but there is a considerable movement among scientists to enter a self-denying ordinance that they will not experiment.

BERGMANN: Of course, I agree, everybody agrees with the sentiment. But I do not think it is a valid definition of what we are demanding. There is no experiment in biology that you cannot explain as an experiment either in biological warfare or another field, because the experiment itself doesn't yet constitute an act in the direction of biological warfare. You can say that no country should be permitted to work on bacteria that are resistant to all antibiotics. On the other hand, it is essential that you know a great deal about it, because today our problem in the hospitals is that there are resistant bacteria, and you cannot say we will not permit anybody to work on them.

MEAD: That is basic science. But if you put it in the hands of the military, they add bits of technology to it, and it is then called biological warfare. In the United States, the Atomic Energy Commission tries to stop experimentation, even in private hands, that might help somebody do something with nuclear energy. This we regard as highly reprehensible, the extension of that type of prohibition, even in the name of national security.

We could carry out the sense of what you are saying and also the sense of how we feel about science in general. It may possibly be one of the steps toward obtaining that climate of opinion Dr. von Foerster was discussing that makes the whole community self-regulatory through the incorporation of worldwide values.

It was a point that Wiener made at the end of World War II when the Air Force asked him for some documents that they already had but couldn't find; in the course of the war he had done the work for them about guided missiles. His point after the war was that the particular information he had on guided missiles was useful only for military purposes, so he was not going to give it to them. I think we can make some distinction of that sort; it probably ought to be made, because if we are going to advocate more knowledge and worldwide availability for this knowledge, we have to deal with the dangers.

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REPORT OF WORKING GROUP ON SCIENTIFIC KNOWLEDGE, EDUCATION, AND COMMUNICATION

Rapporteur: W. Michael Reisman

1. We are committed to the creation of a world order of human dignity in which social and political institutions exist and operate to ensure conditions for the optimal self-realization of every member of the world community.

2. Our demand for human dignity is posited on a conception of the human being as an integrated biological, environmental, social, and psychic creature, appropriately equipped to make and influence the entire spectrum of personal and group decisions of the various communities in which he lives.

3. The systematic search for and organization and utilization of knowledge will play an important role in the realization of human dignity. It is indicative of the deep fractionation of thinking about man in the environment that no single word is readily available to designate inclusively the foci of the natural sciences, the social sciences, the humanities, and the arts. We will use the word *knowledge* to refer to all these cognitive activities that bear on making decisions about man in nature.

Knowledge, so understood, does not make decisons but is a requisite component of efficient, economic, and rational decision making. Where practices abusive to man and his environment have been perpetrated under the guise of science, it is retrospectively clear that the knowledge purportedly applied was quite imperfect, often because of the restrictive focus of a single "discipline." A number of points are patent. Along with errors and damage to the physical and political environment, many radical improvements to these same environments have also been made. As for the serious damage that has been done, a markedly improved flow of knowledge will be necessary for rectification. Hence, the movement toward and ultimately the maintenance of a world order of human dignity is not conceivable without a plenary flow of accurate knowledge to all those concerned with making and appraising decisions—at some point in the future, all mankind.

4. In view of the integrality of natural phenomena and natural and social phenomena and the necessarily global scope of human efforts to harness or accommodate to them, we urge the establishment of a global network of institutional arrangements for the purpose of making knowledge, understood most broadly, about all aspects of social process, available in a comprehensive, timely, and efficient manner to those who make, and to those influenced by, the decisions of mankind. All existing institutions should be considered as resources for this task; new institutions will be created and maintained only as they serve the needs of the world community. Institutions, it must be remembered, are not ends in themselves, but only instruments for the realization of shared goals.

Knowledge goals for global planning and decision may be most economically explored in terms of a world knowledge process, composed of focusing on problems, gathering and processing information, and disseminating knowledge to all concerned. There must also be feedback to the knowledge process itself, for an ongoing appraisal of the correspondence of practice to goal. The working

group has considered and organized its recommendations for each of these successive sequences.

Focus

The sustaining focus for the global process of knowledge is the human being, growing in those conditions that stimulate and facilitate the realization of his manifold potentialities and simultaneously take full account of his biological, environmental, psychic, and social character. An informed focus on mankind includes, at a minimum, comprehensiveness, contextuality, and future orientation. Because physical and cultural realities are not a series to discrete events but are integral, interstimulating components of a whole, meaningful observations and beneficial manipulations can be made only with a disciplined and sustained comprehensive focus. What we need, as one scholar has felicitously put it, is a "macroscope," a focusing instrument that will discard trivia and create purposive attention commensurate with the range of interacting data. Contextuality places a particular event in its full context in order to derive its significance. Single technical solutions, whether they are initially physical or social, must be placed in context so that they do not cause new and greater problems. Future-orientation, an aspect of contextuality, extends the interrelation of events through time, obligating decision makers of today to consider the impacts of alternative choices on future generations in future environments. An appropriate focus implies a responsibility to inspect new social institutions in all their probable effects and to consider the diffusion and social effects of new inventions.

Problem-orientation is also an aspect of focus. We refer to the assembly of knowledge tools to deal with the problems generated by demands for the conditions of human dignity. Some scholarship in the past has included a reflexive, artificial reality in which problems were assembled to fit the limited tools that an investigator happened to have. Real problems are shared; their solutions require pooling resources and sharing data.

Gathering and Processing

The acquisition of data about man and his environment and its processing, storage, retrieval, interpretation, and adaptation will necessitate a worldwide network, integrating existing and newly created institutions, adapting available technology and introducing new techniques for more ambitious and increasingly novel knowledge goals. Although improved communications may permit centralized data banks, processing phases should be widely dispersed to optimize data collection and to share the educational potential of these functions in all sectors of the globe. Within an integrated global knowledge system, we recommend that local and regional units gather and process data of inclusive interest and, at the same time, serve as feedback points for the utilization of information at the local level. Given the fluidity of basic research and applied technology in this area, we refrain from more specific recommendations, which often tend to "freeze" the art and offer, instead, this overall set of policy preferences.

The emphasis on policy and function rather than specific techniques gives perspectives in several features of the gathering and processing sequences.

There has been a tendency to confuse artifact and function. The important function, of course, is the efficient processing, storage, and delivery of information to human beings. For several thousand years, civilizations—as opposed to ancient and contemporary folk cultures—have used script as the primary modality for these sequences, with the primary sensory channel linear and visual. These processing techniques have had a diffused and remarkably deep effect on perception in general. Electronic technologly has opened up a variety of other modalities, with an entirely new range of influences on perception. In the future, the full range of modalities and channels should be inventoried, the full range of their contextual effects systematically investigated, and choices of method at particular times should turn on the needs of knowledge consumers, their abilities, the exigencies of the context, and the probable impacts on future behavior.

Many of the problems and possibilities of languages entail both processing and disseminating. Problems of changes and trends in language dominance are particularly topical. The development of new communicational systems tooled to the processing and dissemination of specific types of knowledge should be explored and set in the context of available and protential information systems. There is a full range of communicating techniques using other signs and symbols than words. The exploration of this area may provide a set of rapid and economic ways to increase the processing and dissemination of knowledge.

Dissemination

Knowledge is of scant utility to mankind if it is not delivered to those charged with making and appraising decisions in a timely, economic, and accurate manner. We identify four major dimensions to the global dissemination of knowledge: communication among scientists, communication with political leaders, education, and media communication. These important areas must be considered separately.

1. The integral aspect of natural and social phenomena and the unfortunate fractionation of individual disciplines require constant and intense interchange between knowledge specialists, within and across disciplines. Verbal declarations of the interdisciplinary faith and sporadic and comparatively primitive multidisciplinary conferences are a far cry from the needs of a global community. Entirely new techniques must be explored. Electronic communication portends a new range of channels, and they must be explored and expanded. The potential of the telephone, and conference call, the telelecture, closed TV, teletyping, flying seminars, as well as other adaptations of technology, must be explored.

The techniques of interpersonal communication cannot, of themselves, surmount internal psychological and emotional obstacles, nor can they be absorbed and usefully integrated without a frame of reference sufficiently comprehensive to indicate the relevance of the research of others. We note with sadness the ludicrous "sovereignization" of fragmented and refracted disciplines and the petty arrogance of individual scholars regarding the utility of the intelligence products of other disciplines. The word *discipline* in this connotation is unfortunate, for it affirms by denial the separateness of dis-

ciplines, including the capacity to generalize. Let the point be utterly clear. Anyone with any understanding of the process of enlightenment and any commitment to the life of the mind automatically confesses his permanent inability to know everything about everything, and, indeed, even to know everything about a small subject. The intellectual life is, in the deepest sense, a community experience; a constant sense of one's own incompleteness and dependence on others with special knowledge of other areas of a varied, manifold, but integral reality.

2. Because a complex society charges certain individuals with major public responsibilities and functions, these decision makers will have exceptional requirements for knowledge, and an understanding, in the most comprehensive sense, of the process of change. In the past, without being so equipped, political leaders have even defined the goals of knowledge specialists and used the knowledge acquired for their own special interests. We believe that knowledge must be used for all mankind, but we recognize the unique demands of specialized political communication. A number of points are clear. First, that political systems are inextricably intertwined with the knowledge process and that a commitment to a global system of human dignity carries with it a commitment to political structures posited on, working toward, and incorporating principles of human dignity.

Whatever the specific structures such systems may take, the special educational needs of decision makers should be emphasized. Decision makers must be equipped with a broad frame of reference that permits them to identify problems and to trace through time the aggregate consequences on man and his environment of the alternate courses of action open to him. We would also recommend the development of education for policy making and for decision making and, in particular, techniques for processing, storing, retrieving, interpreting, and applying the decision experience of individuals; this is a resource that, it seems, is not systematically exploited. In the future, planning goals for increasingly available conditions of human dignity may require more knowledge, and this may become an institutionalized component of global decision making. We note, in this context, Warren S. McCulloch's principle of the redundancy of potential command when information constitutes authority.

3. Every phase of the global knowledge process comprehends learning and relearning. But the sequences of dissemination turn on education in a special sense. First, it is clear that the availability of knowledge assures neither that it can and will be used nor that, if used, it will be used well. Appreciation of the relevance of science to decisions about man and society and the environment and the ability to use that knowledge implies a breadth and depth of education that go far beyond our current goals. Hence, unless the general member of the world community of the future is equipped with a sufficient education, the availability of kowledge will be of no personal use to him, nor, in particular, will he be able to share in the power processes of the various communities in which he lives. Second, a focus on mankind implies a concern with the optimal development of the manifold talents of man, so that he can serve himself, so that he can change or accommodate himself to his plenary environment.

One of the first priorities is more learning about learning. We recommend that man's learning be consciously extended beyond the limits of institutions, through all his life. We emphasize as well that it must be extended forward to birth and even to the fetal state. Because of institutional myths and administrative conveniences, the fantastic learning capacities of the preprimary years have been squandered. We urge that they be utilized.

Education does not mean the colonization of data bits in the neurons of unwilling subjects. It aims at the development of a creative attitude toward knowledge and experience—not a mere accumulation of fact. It means, in short, equipping individuals with the capacity to learn. Education must be premised on the whole man and woman, engaging not only his cognitive activities, but all others—political, affective, playful, and so on. It must include the development of a multitalented human being, optimally equipped for a range of activities—planning, creating, forecasting, decision making, communicating, and many others. The process of education should develop free inquiry and the concomitant self-confidence in imagination and institution that this implies. It should foster plurality and divergence, a capacity for play with ideas, and hospitality toward those of others. It should encourage both associative and analogical thinking. The enormous potentials for inventiveness within a limited framework, as well as the refashioning of ever broader frameworks, must be conveyed.

Particular emphasis must be directed to the teacher, a term that, in its full contemporary connotation, may be a misnomer. Teaching entails reciprocal learning, not one-way communication. In our world of high-velocity change, the teacher who has ceased to learn has ceased to teach. In particular, the problem of the generation gap should be perceived as a reciprocal educational problem. Generations separated by a tremendous experience gap and peoples of extraordinary diversity of previous and future cultural experience will be in continuous contact. This can be either mutually destructive or mutually reinforcing. Teaching and learning can no longer be a linear process from those who know to those who do not know yet, as it has been in the past, but a process by which those who have one form of experience or one current form of knowledge or expertise, wisdom, or inspiration are in mutual communication with each other. In such a system, the teacher of a three-year-old will have to learn first about the experience of that three-year-old, new and unknown to that teacher, because no one will ever have been a three-year-old in just that cultural and situational state. Similarly, the experience of the old, now carelessly disregarded, will be cherished and placed in context as equally precious because, just as the experience of the young today has never existed before, so the experience of each older group will never exist in that form again. The extent to which the experience of each age group differs in a rapidly changing society will have to be recognized in a new design for educational institutions to which individuals will periodically return, or in which they will periodically participate as both learners and teachers. The knowledge and habits of living needed by men and women and children in our changing society will need continuous responsible reviewing, renewing, and innovation.

New environmental needs will require a new technology of learning a new conception of the congruence of learning and living and a full appreciation of the regional and local variations of knowledge diffusion in a multilingual world. We commend to scholars the urgent consideration of these challenges.

4. The media represent a major opportunity for the dissemination of knowledge about decisions affecting man and his environment to the widest audience. We view them as a resource and urge that they be viewed functionally as a public utility of the world community aimed at realizing the most inclusive

interests. We urge that the media be exploited to the fullest as a modality for enhancing the conditions of learning for all mankind. Where the media permit a vaulting over intermediate stages, this should be done. There is no inexorable progression in the adaptation of knowledge for an improvement of life.

Accordingly, we recommend to the plenary conference:

1. Within the framework of WAAS the establishment of an effective worldwide institution to monitor the flow of knowledge relevant to man and his environment in transition. This institution would provisionally be called the Global Knowledge Center. Its membership policy would seek to transcend the transient political divisions of political leaders. It would perform among others the following functions:

—establish goals and priorities for the processing of knowledge relevant to global decisions.

—establish contact with existing international regional and national centers of knowledge, creating thereby a functional grid for the collection, processing, and dissemination of knowledge. To this end, GKC might seek consultative status with appropriate international intergovernmental agencies,

—encourage the establishment of new knowledge centers that it deems necessary,

—recommend the allocation of funds for the establishment and maintenance of such centers as are deemed appropriate to the most inclusive community goals,

—publish timely reports of the world knowledge system as well as substantive levels of knowledge in all areas relevant to decisions of global impact,

—foster an ongoing study of the world knowledge process within the framework of the World Academy and regional and national universities and, in particular, encourage innovations in gathering, processing, and disseminating knowledge.

2. That an interim committee be formed and be charged with the drafting of plans and a statute for GKC and that the Committee return its report and recommendations at the next conference.

3. That a number of crucial problems, some of immediate and some of prospective importance, be initially studied by WAAS or under its auspices and that these same studies, relevant to the global knowledge process, be thereafter transferred to GKC or one of its associated institutions. Among these problems and projects are:

—the monitoring and correlation of different developments in a number of countries in order to speed up the entire process of the advancement of knowledge and to avoid the waste of valuable funds for work that has already been done,

—studies of cognitive processes that might facilitate learning.

—the optimal integration of hardware and software,

—the complex of matters relating to population control: the development of contextual and conceptual demographic models,

—new techniques for the storage and delivery of different types of data and knowledge.

4. That governments and international organizations increase significantly the funds for research about the global knowledge process and about specific areas of substantive knowledge. In particular, we recommend that the distinction between basic and applied research be suspended, because the two interlock and are equally important. The content of the terms is often parochial: what is basic and what applied shifts with perspective, with time, and with the problems encountered.

Combined Meeting of Working Groups
DECISION PROCESSES AND ECONOMIC AND SOCIAL POLICY

Moderators: Myres McDougal, Jan Tinbergen

TINBERGEN: I will take the liberty of explaining what we have been discussing in the Working Group on Economic and Social Policy. Our feelings are that socioeconomic policies can be more or less based on a long-term view. That is, such policy has to formulate its targets or goals around the year 1990, which is 20 years from now, in order to be able to introduce needed changes, perhaps radical changes in certain things; but these cannot be introduced at once, as everybody knows. There do exist, now, a number of reports on the next ten years. There is the Pearson Report; there is also, in the United States, the Peterson Report. On the international level, there is the United Nations Development Planning Committee Report.

These are beginnings, but we feel that even though some of the elements of the Pearson report, for example, do represent a good start, it does not go far enough toward solving a number of future problems, and so we feel that this is one of the reasons why we should take a longer view and should formulate the goals, then the means to attain the goals in that 20-year period. For us, the word goals simply emphasizes everything we want to attain, not only in economics, but the wider social goals, including such things as educational goals, changes in privileges as they now exist in a number of societies, structural changes of different kinds, not only industrial structure, but social structure—that is, human relationships. So *goals* for us is a very wide word; we have decided to list, later, some of the most important so that we can see some of the most important problems that can be solved during that period.

With regard to the means, we agree that on the one hand some of the obvious problems will be solved almost automatically by the price mechanism, provided that a better system of pricing is introduced, and that some of the new costs caused by pollution and by scarcity of exhaustible resources, and so forth are included in the pricing.

But we also feel that one cannot fully rely on these automatic solutions. On the contrary, a number of new public tasks will have to be developed to take care of some of the new and pressing problems that the world is facing. With regard to these new tasks, we attach importance to indicating what is the most appropriate level on which decision making has to take place, because there are different levels. Some things can be decided locally, others can be decided nationally, but there are others that can be effected only supernationally, at a higher level than the national level, and the question arises, "What are the technical principles?" To a large extent, this is a technicality, this is not a question of choice, so certain problems can be solved only if the level of decision making is sufficiently high to take into account the so-called external effects.

I would recall what some of the lawyers have said here. Imagine that with the existing machinery you try to solve problems only by negotiations between autonomous nations. Then it may very well occur that you do not arrive at the right solutions with that machinery.

As an example, I mentioned, of course, commodity agreements. In this matter you may still say that there are agreements among governments. But there are other cases where decisions of one government harm the interests of other governments, and they cannot be left to join or not to join the agreement. But that decision must be made by a vote taken at a higher level, and then everybody has to comply with the result of that vote. That is the new element, and here we feel that the existing machinery is not sufficient, that there has to be created a new machinery. And here we add the very point that is the responsibility of the lawyers, namely, the question of the organization's reward. This is why we would like to exchange ideas with you.

MCDOUGAL: I would like to pursue this point a little. We need to know your problem in just a little more detail. You mentioned commodity agreements and you suggested that negotiations between states might not be enough to handle this. I am not quite sure whether you suggested that parties other than states should be brought into the negotiations or that perhaps there should be some higher body, in which the states would have a voice, that would make decisions without any minority vetoes. If you could spell out this problem just a little more and what you think would be needed, then perhaps we could contribute more.

TINBERGEN: You got to the very heart of the problem, in my opinion. Let me take as an example the sugar agreement, which is one of those commodity agreements that have not been successful, in contradistinction to the wheat agreement, which has been relatively successful. A number of states, including the Common Market and the United States, have refused to joint the sugar agreement.

This is to the detriment of considerable portions of the developing world who are sugar producers, and one of the worst features of the present situation is that sugar is being produced in the Common Market at much too high a price, and the Common Market simply cannot continue to do this because they refuse to join the agreement. We feel that here there should be an international body, whether it is the Economic and Social Council or the General Assembly (hopefully with a different voting system, because I think a voting system in which Luxemburg has the same vote as the United States is ridiculous). A body comparable to that body should be entitled to impose an agreement on the nations by taking a majority vote or a qualified majority vote. If you would like some examples of how such things have already occurred, there is the Federal Government of the United States, or the Federal Government of Germany, and there are some very weak attempts in the Common Market where the Commission has a certain power, and where the Council of Ministers, the ultimate authority, in some cases has to take decisions. And once the decision is taken, it has to be carried through.

MCDOUGAL: Is there any organization of states that includes both producers and consumers of sugar?

TINBERGEN: Not for the time being.

MCDOUGAL: Is there a cartel that controls this?

TINBERGEN: Not for the time being. It is not that I think the sugar agreement is so important, but I think it is an excellent textbook example of what I had in mind. Actually, we think that more important decisions will have to be made in the field of financial transfers, sometimes called aid; I think *financial transfers* or *flows* is a better word.

MCDOUGAL: What runs through my mind, at least on first impression, is

that it would be quite unlikely that the states of the world would be willing to submit this to the General Assembly; perhaps you could get another body, more representative of the common interests.

TINBERGEN: I agree, and we have not discussed that in any detail. But all the members do agree that in the present situation the General Assembly would not be an appropriate body.

MCDOUGAL: One of the things some of us have been thinking of recommending from our group was more compulsory application of the relevant international law. There have been some very striking recent developments; in the new convention on the law of treaties that was formulated in 1969, there is a provision that was first sought by the United States and Western Europe, over the opposition of Asia and Africa. Then, after the Asians and Africans beat the United States on what they wanted, they came back with their own proposal, which, except for the words, was indistinguishable from the proposal made by Western Europe and the United States, which said, in effect, "provide for compulsory arbitration in a convention." I think this is a tremendous step forward. There is also a step forward in some of the procedures set up by the World Bank.

You are proposing to go a little further, and this is not simply the application of the previous policy, but this approach is the making of policy for a whole industry and perhaps a whole series of industries, though I suppose price fixing could be brought within ordinary administrative application functions. But what I am trying to get at is that we should get some comparable procedure that the state plausibly might accept. Of course, I have no objection to making long-term proposals, but if we could get something that we might begin to move toward rather quickly, it would be better.

The procedure in a convention is for each state to nominate a panel of two experts; the United Nations will maintain a panel of experts to which reference will ultimately be made for resolution of all these controversies, and theoretically they are not to disguise them, but they are to find the facts, clarify the policy, and make recommendations as to how they ought to be decided. This is about all you can do in the present world in any case. If you could get something comparable here, a panel of experts on each of your commodities who would have the ultimate responsibility for making recommendations, finding the facts, it would be awfully hard for states to refuse to comply with it.

TINBERGEN: I think we certainly want to go beyond that, but we do recognize the usefulness of indicating steps. I can imagine that in the shorter run, say within a couple of years, this might be the only way out.

MCDOUGAL: There is another model in the fisheries convention, which is the only model I know where the states have gone beyond it, in which all the people interested in the fisheries participate in the decision-making process. And the states delegate real power to the participants to make decisions.

Why don't you spell out a little what you would like to have?

TINBERGEN: We may not have come so far as to be able to spell out everything, but we have mentioned three or four main areas in which we feel that international decision making will be critical in the next 20 years. We feel, for instance, that the question of financial flows from developed countries to developing countries should be one of the subjects. I would even say current flows, a current budget for the world at large for the number of well-defined tasks. I think it is generally admitted that these tasks are only a small part of the tasks that are in the hands of nations. But there are some tasks that we indeed feel should be of this kind, and one is the financial flows, the contributions, that have to be made available for development purposes.

The second applies to a number of trade decisions, and we are not so much thinking in terms of single industries—but we feel that there should be whole groups of industries, especially, for instance, the groups of industries that the developing countries need in order to improve their situation, for which free access to the markets of the developed countries is necessary. The third item is probably less difficult to organize. That is questions of research and development. The fourth field is that of technical assistance. These are the four fields that we feel must be considered at the moment. There may also be a few dealing with oceans, there may be a few dealing with pollution of types that have not yet come under regulation.

MCDOUGAL: What about monetary problems?

TINBERGEN: It has been mentioned that we would perhaps like to see the world develop into one monetary unit. We have not discussed that in detail. I have my own views on it. I would like the International Monetary Fund to have some more powers comparable to a central bank for the world at large.

MCDOUGAL: This is an area where I do not purport to have expertise, so I might ask a question: Is there any existing body that would touch on all these things—commodities, promotion of capital, trade decisions, research and development?

TINBERGEN: You could say that the Economic and Social Council reviews all these things, and thereby the General Assembly. I would be in favor of changing the system of voting, and then I would see about making this sort of government. But I think a very considerable change in the voting system would be needed.

MCDOUGAL: Maybe the thing to do is to clarify the policies and recommend the change in the voting system that would be needed to put that into effect.

TINBERGEN: I have one to suggest, but I did not discuss it with my comembers, so it is my personal responsibility. I am going to suggest at NATO this year that we have something like an average between votes, depending on number of inhabitants, and votes depending on contributions made to the United Nations. That is, votes as they are now in the World Bank and in IMF. The reason I do not introduce both elements is because, on the one hand, it would be unrealistic to take only members, and then, of course, the overwhelming power would be in the hands of India or China. On the other hand, let us say, there has been a development in what we call the extended example of parliamentary systems, the British Parliament, which started as a parliament of taxpayers and then developed into a parliament of citizens. And I think this development is probably a reasonable one, and we could negotiate the relative weight given to money and to persons.

MCDOUGAL: Perhaps we should unstructure this a little and let other members of the group respond.

KING: You asked if there is an organization for the developing countries that are likely to emerge. This is exactly the function of OECD, but without any decision-making power.

MCDOUGAL: Would you want to move toward OECD, or would you want to move toward ECOSOC? That is, simply increase the powers, get a working formula. I think the most important contributions you could make would be to make the case for compulsory decision on a great many of these areas and

then leave it to the lawyers, the experts on international organization, to try to come up with a range of alternatives. That might serve your policy. Of course, sometimes the most critical suggestions come from the fellow closest to the problems, and you may see things to which technicians are blind, but your first job is to make a persuasive case for these decisions.

WOLF: Just one point of clarification. When you speak about revision of the voting, do you mean general revision, or for that purpose only?

TINBERGEN: I would like it general.

WOLF: Many people would like a general revision, but I think that it is impossible, because the present voting system, as you know, is provided for by the U. N. Charter. When the Charter was drafted, the world organization was completely different, and each time we tried to establish a weighted voting system, which is what you have in mind, we came to a total impasse. I can understand the desire of certain members to have the system changed for certain purposes. But I am more than skeptical about the possibility.

I think our draft, if it is based on such a formula, is bound to be defeated. Therefore, I think it would be better not to have a new international organization, but to have a special setup, within the existing organization, by which something new could be added to the existing precedents for problems like environment. There, I think, economists and lawyers can join efforts.

You also spoke about technical assistance problems, financing, and so on. In this particular environment, are we really, in your opinion, in the field of technical assistance, and are we confronted with major financing problems? Isn't there, first, a necessity for the developed countries to take some very important measures to fight the consequences of environment with their own money. Also, you say that some decisions will have to be taken on the local level, some on the national level, and some on the international level. Some can be taken *only* on the international level. There I agree, but there are many measures that could very well be taken on the national level but are not being taken. One needs international stimulus.

Just as an example, ILO, in its early years, adopted an unemployment-indemnity shipwreck convention, so that the seafarer who was the victim of shipwreck could get protection, could go home, could have some money. Any maritime state should have taken such a decision in its national framework, but nothing existed; in no country whatsoever was there any national legislation on that point, and it certainly was a national problem. But, when the convention came about, it created an international stimulus that provoked the adoption of the necessary national legislation.

There are points that are appropriate for local or national action; however, often we first need the international stimulus.

PECCEI: I think that we are starting a dialogue of the definite. Many of the positions that have been expressed by Professor McDougal and Mr. Wolf are positions that stem from the present situation, with a very heavy legalistic interpretation of it. I think that many of us at this Conference would like to see if we can leave, for one moment, precedent, and bypass expert legal frames. We have to go beyond today's situation and see if we are able—it is extremely difficult—to imagine what could be a better world in, say, 1990.

Let us see if we can design something new. We are in a revolutionary period. During this Conference, we have heard that there is no precedent for the size of the population we are expecting in 1990, for the possibility of producing goods, of exchanging goods, of modifying human personality; it is

totally another world we must look forward to. Can we imagine, with the background of our culture, and our experience of the past, one moment out of the present constrictions in that world? That is what we propose this Conference should attempt.

There are many other bodies, and Professor Tinbergen has indicated some that are studying the next steps to be taken; we have some 127 nation states; we have a certain body of law, good and bad. But let us go back. When this country was made, it did not lean on existing conceptions. We are entering into human minds, and we are not respecting what is the past. My idea is not to start from here and go there, but to imagine what will be the best situation there, and then come back.

OZBEKHAN: I think Dr. Peccei has said many of the things I wanted to say, although perhaps I might have said them a little differently. What struck me very much in listening to Professor Tinbergen's explication of the situation is that the issues become reduced to the measure of the competence of the institutions that exist today. Ultimately all the solutions of the so-called major problems become drive qualities, the greatest drive quality being the one that you have explained to us—about how the international stimulus created certain national movements, to which certain national decisions were taken.

I do not believe that by such very minor incremental steps anything can be done to change the massive inertia that is the problem of the world today. I believe this is what Dr. Peccei was saying, that somehow or other we have to exercise our imaginations in ways other than those imposed on us by institutions, charters, and everything else like that because, obviously, we are not going to get anywhere.

MCDOUGAL: This is more than a measure of imagination; there is more of mobilizing it forward.

TINBERGEN: I think Mr. Wolf's remarks were quite relevant. If it is true at this moment that you would not get the support of the existing bodies to change the voting system, then you have to indicate how to get there. There has to be a road from now to that better situation. But I feel that scientists, as we are here, can influence public opinion and may make it clear that there is no other solution, and that might help us overcome the present unwillingness. So we must mention necessity in our reports. But then I could also imagine that the action would be through political parties. We have increasingly internationalized political parties, and the political parties are no longer national, but when acting in the Strasbourg Parliament, they have been united. Jean Monnet's work is very relevant in that it shows the possibility of convincing political parties that this is the thing to be done. Moreover, the real point is that the big nations are more powerful, so it seems to me that we should tell the small nations that they have to accept that the present voting system is ridiculous and cannot lead to anything we are in favor of.

KLINEBERG: I would be very unhappy if we projected into the distant future without any idea about how we get there. We need some kind of compromise, perhaps between what looks like two contrasting or contradictory positions. I think we could satisfy the demands of those who want us to dream a little, dream constructively, but I think we also need to indicate what are the immediate steps that can be taken and that can move us now in that direction.

In that connection, I want to raise a question with Dr. Tinbergen. I speak as a layman, but as one who has been around the various international organizations. Many of them, like the ILO, seem to have a great deal of success

in getting the individual member states to follow the covenants or recommendations for certain of the decisions in the General Assembly, which are simply ignored by a member state like South Africa in one case, Israel in another. I wonder whether, in the area of environmental problems, pollution, population problems, et cetera, we could indicate where there is likelihood that this machinery, whether new or introduced into the present machinery, would have a chance of success.

On the basis of preceding experience, do we see certain places to start where there may be a high degree of probability that the beginnings of international agreement and cooperation could be established. Could we move from there to some of the areas where, at the present time, no agreement can be found?

PECCEI: May I make one small comment? I am a practical man. The first step to reach those goals or limits is to conceive the goals.

OZBEKHAN: I agree that we need—aside from the conception of the goals and the conception of the kind of world we need—to know how to get there. I am critical of the fact that somehow or other, burdened as we are with our present experience, the steps we seem to be able to conceive within the current reality are always too small and not commensurate with the nature of the problem we are talking about.

CATLIN: May I suggest that in drafting a report defining a standard need, it could be fairly rhetorical, shall I say, imaginative, a vigorous statement of the dangers of the present position or imagination of a better position. It does not therefore follow that we will disregard or choose to disregard the institutional route. What we need is to be absolutely precise on what we want to do. We don't want to push out an international program with a vast cost where there is a local program that can be tackled more easily. That, I think, is destructive. But we do need convincing scientific evidence that will capture the determination of professional bodies, which are themselves in touch with the levers of power.

DE CASTRO: I suppose that we are facing a major difficulty. Everybody dreams of a better world, so what is the probability of the future if you try to forecast the new world of 1990? Somebody has a model in his mind according to the density of the area in which he lives. So it is not easy to start together, because we don't know where we are going, but indeed a certain number of things are fundamental for the world to continue to exist. We must admit that if we continue in this type of world, we are menaced by disaster, not only economic, but by war and its probability. Among the probabilities, there is the end of humanity. When people say to me that in the year 2000 we will have 6 billion people, I say, "Yes, or nobody." That is our range of probability.

To imagine that as a concrete idea seems not entirely scientific. But we must mix science with imagination. When Einstein conceived his theory, it was not entirely scientific at first. If he had waited to do an experimental demonstration, we would not have the theory of relativity. So let us transpose that to the social arena. We need to build a better world. We need new machinery, and the difficulty there is to know what kind. If we put in new machinery, inside the United Nations by the creation of a new special agency, we create more trouble than solution, because we know that the most difficult problem in the United Nations is coordination among agencies. The Economic and Social Council—what does it really do? Inside the United Nations a new agency is very difficult to create, it seems to me.

To do something not international but supernational, most people say, is a dream that we cannot accomplish. Let us recognize that we scientists have no actual power. So we cannot talk in the name of the government. But we *can* do something different. Professor Tinbergen said that we can represent or work as a pressure group through public opinion to show that there is something better. Perhaps up to now we have talked of what must be done. My position is different. Why not say what is not to be done? We must take a position that contends that we must avoid putting men and the world in a worse condition than they are now.

Professor McDougal asked about maritime problems. It seems to me we must link all the ways, disarmament with development, because if we do not link them, we cannot achieve either disarmament or development. I think that our scientific position must be to announce that the world is in a bad state because we did such and so, and they were mistakes. If we don't want to say that, we can say: "Avoid doing this and that in order to protect the environment, man, and life." We live in a time of contestation, of confrontation. If this confrontation happens in the United Nations, it will be terrible. I believe something should be done that will represent more than a group of facts, something more important than knowledge, and that is judgment. Wisdom, as science suggests, is knowledge plus judgment. In the underdeveloped countries, we are told that we must not do such and so. What is terrible in underdeveloped countries is that we receive recommendations that are exactly the opposite of what should be done.

I am from an underdeveloped country, and from this position I say that people from different cultures think differently. And how to put these different modes of thinking into a framework, that is the job of you law people. I am only a person who observes things, and my experience of development is experience that I did not get from books. I am not an economist, but I have observed the economic, social, and human problems directly in the northeast area of Brazil, where I was born. That is my vital experience, that is what leads me to speak as I have spoken.

TINBERGEN: Almost all the points that have been made make sense to me. On the one hand, we must have an idea of where we want to go. On the other hand, we do not deny that we are somewhere now, and we have to go there from here. So I, for one, feel that the suggestion made by Professor McDougal that in some cases arbitration would help is an improvement.

I think Mr. Wolf also made a good point. It has been proved empirically that sometimes international pressure can help national authorities achieve certain things. So I would agree with that. Even so, I think we have to go beyond that, and perhaps we would first have to convince, through the scientific community, some of the people in power that these are the more effective solutions and maybe that will, after a while, penetrate the heads of more politicians. The third thing is that we may think of creating bodies for solving new problems; the pollution problem is not really new, but it is of new dimensions, and we may endorse the idea that there may be disqualified voting. We can immediately argue that for technical reasons it has to be that way. Fourth, I would propose, even though Mr. Wolf said that it will be voted down, a different voting system in order to get somewhere.

So it seems to me that there are actually four roads open to us, and we must hope that bringing the pressure of events to people will change their minds, maybe not two years from now, but five years from now.

LASSWELL: I am very much struck by the emphasis on preferential models for the future of varying degrees of remoteness, and I think this is a fact that we should remind one another of. I was struck also by the idea that the failure to formulate a measurement, at least of some of these preference models, is the present limitation on our creativity. When we move back to the question of how to move from the present state of predispositions to where we want to get, through time, I wonder if, thus far in your group, you have had some examples of these more imaginatives types of tactics that reference was made to.

TINBERGEN: I think that is, in fact, what was done; on one side the United States was one example, and what was done inside Germany was another, and what is being done in Western Europe is a third, and Mr. Monnet especially has been very helpful. The ideas he has launched have, because of their performance in practical fields, impressed such people as Paul Henri Spaak and others. Finally, we have discussed the Rome Treaty. The government of the six countries have agreed to give up some of their autonomy in well-defined fields. I think this is the way to go. I would not restrict it to Western Europe. I would now try to have it done in what, at least, would be a combination of Western countries and developing countries, and hopefully, even the Eastern countries.

LASSWELL: Is that an example of what you mean by new tactics?

DE CASTRO: I don't agree with Professor Tinbergen.

First, in answer to Dr. Lasswell's question, I would say that in our group we did not come up with any appropriate breakthroughs. But I must admit that we did not have an opportunity to discuss them. We have been engaged in "approach" work. However, I believe that as long as we remain within the purview of known solutions and try to improve on them, there is not going to occur that heuristic and conceptual breakthrough that is absolutely necessary. Hence, I believe that in some profound sense—and I say this very humbly—the whole methodology of approach is wrong. It is always wrong, heuristically speaking, whenever in a crisis situation that which is believed to be practical is applied to the case.

We then proceed in the light of our extremely restricted understanding of practicality to meet a problem that is considerably beyond the powers of our knowledge and our capabilities. And I am not saying this just in terms of individuals, but also of governments, of ministers, of whole peoples and nations, of the students who are in the streets—they are not in the streets just for the fun of it. We are therefore, confronted with a true and major and critical problem, and, in fact, if the very work and concept *problem* does not apply, we are confronted with an almost insoluble situation. We cannot live according to the criteria that have defined practicality before this situation occurred.

MCDOUGAL: Can you be more constructive?

TINBERGEN: May I just say that I do agree with Dr. de Castro. My second approach, which I call the approach through the scientific community—

MCDOUGAL: What do we say next?

DE CASTRO: What we say next is precisely that we have to come around to recognizing certain things that we have not introduced into the argument—namely, we have not introduced the dimensions of the kind of world for which

we ought to aim. We keep not doing it because we always think this: it is a utopian kind of thing and it is just a revery of one kind or another, which, in itself, is a limiting factor. The second thing we have not introduced here—because we have given up our philosophical framework—is the fundamental base by which the human being solves problems: the ethic. We always operate from a certain given value system and a particular ethic, which today has become totally irrelevant as far as I am concerned.

WOLF: I would like to clear up a misunderstanding. The example of the shipwreck convention was simply a technical illustration of what can be done on the national level. Let us forget the shipwreck convention. We have left our traditional framework to deal with, for instance, our own regulations on fundamental human rights, on apartheid, and on the world employment program. There we have invented, and we must continue to invent. So you see that we, the international organizations, all the expertise throughout the world, using the universities and the study and research centers as tools to stimulate our own imaginations, *we* must find new solutions. What I meant to say is that we *have* succeeded in some things, such as conventions on human rights, forced labor, discrimination, and that is what I had in mind.

TINBERGEN: This combined meeting has been very useful, and we can go on in our Working Group now, with certain new ideas. We agree that we have to indicate very recent steps, including the imaginative steps that Dr. Ozbekhan cited so forcefully and that I am certainly not against.

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Working Group

DECISION PROCESSES CONFLICT RESOLUTION AND THE CONTROL OF WAR THE ORGANIZED PLANET HUMAN RIGHTS AND INDIVIDUAL PARTICIPATION *

Chairman: Myres S. McDougal

Participants: George E. G. Catlin, Yehezkel Dror, Philip C. Jessup, Otto Klineberg, Ervand Kogbetliantz, Maurice Marois, Oscar Schachter, Burns Weston, Francis Wolf.

CATLIN: A primary difficulty, of course, on all international law questions, in eminent books on the rules of law, is the comment of Andrew Jackson to John Marshall: "You, John Marshall, have delivered the decision; now who will execute it?" In other words, unless we are going to rely on something as vague as public opinion, it is difficult to see how we can detach the judiciary from the executive. The executive becomes of key importance; the two cannot be divorced; your total complex has to include the judicial and executive and also undertake the problem of whether you go on precedent or require new legislation.

Second, on the question of the executive, I am not so foolish as not to know that the rule of reason is fragile, and, in the words of Aristotle, "The intellect moves nothing." If you can get consensus, which used to be a blessed word and now has become a not-so-blessed word, that is excellent; it is optimistic and depends on your time range. How long you are going to take to get the consensus that you are thinking of—decades or centuries, or more?

I sometimes am forced to think that the only realistic answer is revival of the Roman Empire, and if you have Augustus Caesar restored, a lot of nonsense will be terminated. I saw that King Hussein announced that the only satisfactory thing would be an imposed peace. Who is going to impose it? It is not such total nonsense. That is the kind of world consensus that the world government people have always aimed at as an admirable aspiration, but not, I think, of our century. A condominium of the superpowers, which would naturally be resented by all such countries as Yugoslavia, is by no means out of the question and is, indeed, marginal in a Middle Eastern position, although patently not yet reached.

A last comment—on human rights. Of course, we had civil liberties and human rights, and John Locke and the rest drew them up, and of all the human rights, the most important was the right of private property. They took a pepper pot and peppered in whatever they thought was admirable and said that this was a natural right. I am frank to say this seems to be a matter of subjective preference. I think there is such a thing as natural law. I think it can be tested by logic and could be tested experimentally—I was also going to say "by medicine"

* Two sessions of these deliberations were recorded by the stenotypists, thus providing only a brief synopsis of the Group's work. However, the report of this Working Group is quite detailed and therefore is an excellent summary of the discussions—*Eds.*

—what conduces to human health. This I would say is natural law, and what we can derive from that is valid.

I always remember one eminent left-wing politician talking about the city of Glasgow, saying that the city fathers of Glasgow had forbidden children to play in the streets; but since they had not provided any playgrounds, this was unnatural law, because there was nowhere left for children to play. But if you go beyond that natural-law position to natural rights and, still more, to civil liberties, it seems to me we are left with what is simply an opportunistic position, because civil rights are what *we* decide to be *your* civil rights. We say it is a civil right for every man to carry arms, it is a denial of civil rights to forbid man to drink liquor, and various other things.

KLINEBERG: In all of the proposals that are made, whether by lawyers or by political scientists or others, we strike against this phenomenon—I am being very obvious—of national identity, national loyalty, and the line of demarcation is nationalism and chauvinism is often very difficult to draw. We try, I think, to defend ourselves when we speak about chauvinism and not about nationalism, because we know we will run into all kinds of resistance if we say that nationalism is the great scourge of mankind. I am suggesting that we take a hard look at what we mean by a healthy nationalism as compared with an unhealthy chauvinism, whether there is such a thing as healthy nationalism, what kind of national loyalties are compatible with the rule of law at the international level?

With regard to human rights: Instead of arguing about what human rights are and whether there are natural rights, we should perhaps start with the International Declaration or Covenant on Human Rights. The declaration has been accepted by enough of the nations of the world to make it a document that we could use as a base and then raise the question: Do we have any recommendations about implementing those rights, do we see any ways of bringing them a little closer to reality? This brings us to the whole problem, partly a psychological one, of what we know about changing and improving attitudes that would make the realization of human rights a little more possible.

SCHACHTER: I suppose the group would want to come out with some ideas or recommendations on the organized structure of the international community; the kind of arrangements, formal and less formal, that are needed for environmental and related problems. If we can take a starting point national feelings and national property, areas of national competence, it seems to me that we must move quickly into the kind of procedures and arrangements that would be desirable for meeting the dependencies of nations on each other.

My own ideas are in the direction of a rather complicated kind of pluralism; international, with a great variety of structures that would be regional, perhaps ecologically regional, would be functional in appropriate cases for things like multinational corporations. But it would also be linked up with the larger aggregates, the global bodies, the United Nations, the ILO, and the other bodies in a way that we could combine a sense of participation by those people who are directly concerned, and a sense that they are acting legitimately, keeping the wider principle of international order so that minorities are not ganged up on and nonmembers are appropriately safeguarded when necessary. This is a very complicated business, and I do not suppose one can quickly or even wisely try to do a detailed blueprint, but I think some of the basic lines of this are particularly important in the environmental thing because I am rather skeptical about a globalism that would embrace all subjects, all topics, and all areas of the world.

MCDOUGAL: I would like to know why you don't like the Kennan proposal,

what objections you have. Could you give us just a little detail of how you perceive this coordination?

KLINEBERG: Which Kennan proposal are you talking about?

MCDOUGAL: In a recent issue of Foreign Affairs, he proposed a special international organization for various functions with respect to the environment, primarily what we call an intelligence-promotion-appraisal function, not a lawmaking function.

SCHACHTER: I am not sure whether I am opposed to that, actually. I think there has to be some sort of framework on the global scale for information.

MCDOUGAL: Some new framework?

SCHACHTER: Things called promotional activities. But I would test this against such questions as the extent to which you could get significant participation by the organization, state, or individuals in that process. It seems to me that in the light of the nationalism that preceding speakers have emphasized, one must take account of this sense that there must be a more direct feeling and more direct sense of participation on the part of those directly concerned. That is, more not only for nationalist reasons but for personal reasons, for the involvement of people. I would say this is not only a regional matter but, possibly, a functional matter. Professional groups may do better by being organized as such than by being merged into a general organization.

Now it is quite possible to say, "Well, you can have both," and to say that they all should fit in. I don't think that follows. In fact, I think that there are really quite different choices, because if you merge everybody that way, you get an organization with which I am as familiar, I suppose, as anybody around this table, the General Assembly of the United Nations, with which I have lived for a quarter of a century. The General Assembly of the United Nations is not the right body to operate a kind of elaborate protective system. And putting organizations within the framework of the Assembly of a professional or regional kind calls for a great deal of skill and care. As I say, there has to be a relationship. One has to have both of these things—an expression or a framework or an expression of global interest, perhaps a kind of semi-quasi-policing function; maybe that is carrying the word too far, a kind of stimulating function, protective, seeing where there are spots that are not dealt with appropriately, perhaps a legitimizing function where that is important, as it might well be. But in order to get the real work done and get people involved, get them down to dirtying their fingers and dirtying their hands on the real work, you need more specialized groups.

MCDOUGAL: Both functional and regional?

SCHACHTER: Yes. I suppose they cover everything ecological, professional, functional—it depends on what meanings you give them.

WESTON: Governmental?

SCHACHTER: Yes, and one of the things I would like to see is a good deal of nongovernmental activity in this, but that is a personal bias. I would like to get away from the international bureaucracy to which I have belonged for so long and to bring in a much wider body of participants.

SCHACHTER: One of my answers to George Kennan, who came to speak with me before he wrote about it, may well turn out that the International Oceanic Commission may develop so that it will be far more efficient than this unknown organization. One must look to the governments behind, the interests represented in, say, fisheries and numerous other fields; they are not going to disappear because a new framework has been created. We have to concern ourselves

with how they are going to continue to work and have the right input. To put a generalist over all these people is a superficial way of reaching an interdisciplinary approach, and that is why I am skeptical of it, but not in the sense that I want *no* global side. They must all be there, and I don't think, at least I could not think, of writing this all out. I think it is going to have to be worked out over some period of time.

MCDOUGAL: Suppose, Oscar, you were not going to create any new specialized institution; how would you go about improving the existing functioning of the United Nations and regional organizations?

SCHACHTER: You would end up doing the same thing. That is to say, you could improve it only by introducing the kind of specialized units within that structure that will attract people who are competent to do the work, and they won't be attracted unless they have some responsibility and adequate remuneration, et cetera. But I am stressing responsibility and a reasonable amount of autonomy. You might have multinational enterprises created within the United Nations or outside it. The trouble with creating it within the United Nations is the problem of global majorities.

KLINEBERG: But the individual countries that are in the minority have a feeling that the group as a whole is against them.

SCHACHTER: Canada is a country that is strongly nationalist at the moment on these issues. Canada would not feel that its Arctic problems could be adequately met by votes in the General Assembly.

WESTON: I am not quite sure I see the role of this group in terms of control of coercion or war. Of itself, that seems to be such an enormous undertaking, and most of the people at this Conference are concerned largely with environmental problems—not that control of coercion is not an environmental problem, but it seems to me the essential focus ought to be on the environment.

I agree that the essential goal of this particular group ought to be to clarify those policies we deem important and then to devise strategies by which they can be effectuated. Should those strategies be done through the pursuit of the establishment of new organizational arrangements, new institutional arrangements, functional or governmental, private versus public; or do we want to devise strategies that will pertain to the restructuring or the making more effective of existing institutions? I think we have to worry about the strategic level of our concerns as well as the goals themselves.

KOGBETLIANTZ: I think it is impossible for us to elaborate the strategy to control war. It is out of our range. But we should probably express our opinion on the extreme danger for mankind of another war. Simply a resolution. It may have some value.

WESTON: If we are going to concern ourselves with environmental questions predominantly, one of the major ways to begin discussing them in any effective sense is to begin asking who are the people around the world, in group or individual capacity, who present environmental problems. That would give us some feedback for making the kinds of policy recommendations that ultimately ought to be made.

WOLF: Like all of us, I am a very strong believer in international instruments and in matters that affect the whole world in multilateral instruments. We have built up, stage by stage on specific points through the 51 years in the ILO and in the International Labor Board Code that deals with all aspects of the conditions of the worker. It represents today 130 conventions that have obtained, from our 121 member states, a total of 3,500 ratifications since 1926,

with efficient control machinery that has permitted us to evaluate on a regular basis and in great detail the conformity of national legislation, national practice, national judicial decisions with the international rules contained in the conventions, accepted, ratified freely by the governments. Whenever that machinery has noted discrepancy between the international text and the national legislations practiced in judicial decision, we have obtained changes—in the national legislation of Latin American countries, Asian countries, African countries, European countries, and even the U.S.S.R.

In the world as it is organized at present, the control machinery could not work if it were just a matter between the two great powers. It is the whole world that is associated for the building of that core of international instruments. I think this would be the right way to follow in all fields, not only in labor, but in each organization in its own field, in close cooperation. I think the coordinating problem is perhaps one of the most important of all, not only among the United Nations family, where an elaborate coordinating machinery exists. I think everything is interrelated, whether it is law or science or diplomatic or political legislation or labor legislation, because we are under the auspices of the scientific.

Just a few more words on the problem of participation. This, too, is one of our major preoccupations. We started the World Employment Program in a very modest way. The first conventions—and there I come directly to the environment—really dealt with the environment of the worker, and were those that protected the workers against the risk of white phosphorus. Many of our conventions deal with environmental problems for the workers. Hygiene, health and hygiene in offices, in industry, health problems for children, for women. We were the first to have an international convention against ionizing radiation, and now we are preparing an international instrument against the risks arising out of the use of benzene and products containing benzene. We will ask the member states to accept that wherever the benzene substance or products containing benzene can be replaced by other, less harmful products, it shall be done, and that research should be pursued to replace it by a new product and that benzene should be kept only for research. One must start *petit à petit* to build up a code that will be a world code, if you take everything together on environment.

We have part of it. We have the principles in the Universal Declaration of Human Rights; we have some of their principles in the Covenants, and more and more principles in the International Labor Convention.

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SCHACHTER: I'm afraid legal groups rarely discuss the environment in broad, comprehensive terms. They normally discuss rather specific, concrete questions, and in that sense environment is entering into their thinking, but not so much basic law.

LASSWELL: I have only two suggestions to offer. The sense that all of us have is that we want to clarify the form of the world decision process that would be adequate for the realization of an adequate environmental policy for man. Putting it broadly, this is the general objective. At the same time, I think we recognize, given the present degree of interest in the environment, that we want also to consider how to use that interest in such a way that it will contribute to the realization of the remolded and improved decision process. I say this because I think it may have some effect on the way in which we formulate the policy papers that come out of our deliberations.

So there is the double aspect: One is the decision process that will enable us to function in the world community effectively, including, of course, our environmental objectives. This will call for a consideration of the policy process that will realize the technological level of operations that will be essential to achieve the environmental effects. It will also call for the clarification of the ways by which we can mobilize the existing and potential motivations of various territorialistic groups, official and unofficial, to increase the probabliity that what we are concerned about can be brought more into effective existence.

In the documents that were circulated as working papers, some reference was made to the technical aspects of the problem—that is, what the scientists and engineers who have specialized on different components of the environment have to say that is pertinent about the technological activities, the objectives, and modes of operation. Then we consider the administrative and legal process, which should be more adequately rephrased as the constitutive decision process. What constitutive decision process needs to be consolidated and improved in the world community? And how do we mobilize, taking advantage of available predisposition, and move toward the objectives that we are concerned with rendering effective?

It might be that we will eventually want to adopt a phrase in which we talk about human rights other than those in the environment, in this way mobilizing all the sentiment and all the technical implementation thus far in order to focus it on the realization of these environmental goals. And it could be that this would turn out to be one of the ways of formulating the suggestion. The constitutive framework is precisely what is on point with respect to the decision process. This then calls for further elaboration with regard to the other objectives of the public order.

Then I would suppose that strategy would be used as the details of the way in which the constitutive or decision process could be effectively handled, and the strategies of mobilizing support in order to accomplish the purposes through the time that we are interested in.

MCDOUGAL: I put the last two things a little differently. I suggest what we could contribute best may be one recommendation of policies on the features, and suggestions of alternatives for achieving those policies. But we could not really go into the trend or factors effecting them. We want details on the processes, how they can be modified, and the strategies for mobilizing predispositions to effect those things.

LASSWELL: I don't think we are saying anything at cross-purposes. I think that perhaps what you phrased is the constitutive process, the characteristics of the constitutive process in the decision process and other aspects of the public order process that there would be an expression of, however, together in articulating the detail.

KLINEBERG: I am a little puzzled, because as I read our working paper on control of coercion and the organized world, it did not seem to me to be restricted, or even related directly to the problem of the environment. It was couched in much more general terms.

MCDOUGAL: We want to keep it that way.

KLINEBERG: In other words, we are interested not only in, let us say, international law as related to specific environmental problems, but in international law as a means of keeping the world at peace? Is that correct? I just want to know how to interpret this, because in so much of the discussion we have come back to the environment, and I wondered if that was our focus.

LASSWELL: What we are concerned with here grows out of the larger concern of the people who initiated this series of conferences with the larger objective, the designing of effective institutions for a more satisfactory world public order. That is essential. The emphasis on the environment is perceived not only as what should be included in that enterprise; the interest in environment provides assets for mobilizing interest and concern for the improvement of the general decision process of the community.

MCDOUGAL: Anything we can do to improve the process for the environment will probably also improve the process for problems; these are not mutually exclusive approaches, and some of us have devoted a large part of our professional careers to working on things like this, and we feel a little more comfortable working with decision processes than working with environment. We are trying to educate ourselves a little on environment and are taking advantage of these expert witnesses before they disappear.

I will come to Mr. Wolf, and see if we can develop his notions of a world code. You threw out a very intriguing idea, and there have been a great many organizations affecting the environment that might operate in somewhat the same way the ILO operates; I think we should explore that in immediate detail; if there are enough existing organizations that could operate that way, conceivably we could cover all of the major particular problems that relate to the environment. You might tell us how the ILO *does* operate, and then we will come back and consider who might be stimulated to do likewise.

WOLF: As you know, the International Labor Conference, which meets once a year, normally adopts international instruments, conventions, that are subject to ratification. All governments, whether they have voted for or against a convention at the conference, are compelled to submit the convention to the competent authority.

KLINEBERG: Who proposes the conventions? How do they get into the works at the ILO?

WOLF: The agenda of the yearly meeting is fixed by the governing body on the basis of proposals that may come from governments or from international or national organizations.

KLINEBERG: Or from the Secretariat itself?

WOLF: In the Secretariat there are prepared summaries on law and practice on the questions that are considered for the agenda of the conference.

MCDOUGAL: Who proposes the convention?

WOLF: One proposes the item on the agenda. It will be for the conference to decide whether it takes the form of a convention or of a recommendation. Let us say that the question of protection against radiation is on the agenda or is contemplated for inclusion on it. The Secretariat, the International Labor Office, prepares a summary on law and practice for the governing body, indicating what the various health legislation, industrial health legislation, is in the different countries, how far the problems have advanced in these countries.

KLINEBERG: But the original proposal to put a certain item on the agenda—

WOLF: Can come from the Government.

MCDOUGAL: The pressure groups may operate on the government level?

WOLF: At this stage I would not speak of pressure groups, because what would normally be a pressure group is represented, since the governing body is tripartite.

KOGBETLIANTZ: How is the governing body elected?

WOLF: By the conference. There are 48 members, 24 governments, 12 employers, 12 workers, all of whom, except the 10 chief industrial state government representatives, are elected by the Congress.

LASSWELL: The Secretariat does not take initiatives, formally speaking?

WOLF: No, the agenda says that it may be made by the government of any of the members or by any representative organization in the sense of the constitution, or by any public international organization.

KLINEBERG: Forgive me for breaking in, I have a certain experience with UNESCO, and there, very often, the Secretariat would prepare a paper that would go up in the hierarchy, be accepted by the Governor General, and then presented to the governing board.

WOLF: When the governing body decides, normally 18 months in advance, what the agenda of the conference will be—in November, 1969, the agenda was prepared for June, 1971—then the office prepares papers on the various items considered, indicating the law and practice in all the countries on the basis of our information, of our library, on the studies of our experts. It is on the basis of those papers that the governing body makes its choice. The governing body cannot handle all the agenda, and we have two or three technical items each year.

Once the governing body has decided to put something on the agenda, we prepare a questionnaire, which is sent to all governments, and the governments have to communicate the questionnaires to the workers' and employers' organizations for their own comments. The governments give their reply to our questionnaire, and we prepare a first-draft conclusion. Then we go to the conference for a first discussion, where everything is discussed on a tripartite basis. After the first discussion, we prepare a new text representing the outcome of the conference, which we lawyers look at very carefully. We send it to the governments for their comments; we revise our text on the basis of the comments of the governments, always concerned with the nongovernment organizations, and we go to the conference the second year for the final decision. And then the conference can decide whether it will be a convention or a recommendation.

The important factor in the organization is that we have the individuals directly concerned, who take part in the framing and in the voting of those conventions, workers and employers. They vote on an equal footing with the government representatives. The only difference is there are two government representatives, one employer and one worker for each country. The conference adopts the text, and the text has to be submitted to the national authority, normally the parliament, which means that even if the government has voted against the text, it can be submitted to the people's representatives in parliament and they can ratify it, even if the government representative was against it. Once it is ratified, then there is an obligation among the members who have ratified among themselves and an obligation on the member *vis-à-vis* the organization as a whole, which is the starting point for our control machinery.

That system has been followed for quite a number of other instruments, and in the Covenants you find a similar system of control machinery. You find it also in UNESCO for the discrimination-in-education convention, you find it in regional organizations, in such instruments as the European Charter. Also, we have, outside the proper framework of the ILO, taken part or organized or initiated instruments for other organizations for regional groups.

MCDOUGAL: How many different features of the environment could the ILO affect?

WOLF: The central point of all the conventions, whether in agriculture, whether a special part of the entire labor code, is always the condition of the

workers, and in many respects you will find that this applies to the environment. We have conventions on accommodation on board ships. What is that if it is not a very special aspect of environment? We have the conventions on mines, on underground work for women, for young people, for children, et cetera. It is environment. More typically, environment probably applies to those who deal directly with health and hygiene in industry or in commerce problems.

WESTON: May I ask you a fairly lawyerlike kind of question? You indicated that the conference makes the determination as to whether what is on the agenda will take a recommendation.

WOLF: Excuse me, the governing body.

WESTON: Two questions with respect to whether the final product will take a recommending or convention form: One, can you give us some indication of the ratio of that which is recommended versus that which results in conventions? Second, are there any criteria that you can isolate that indicate why it goes into recommending rather than convention form? And then, if it is recommended—I realize that that may not have, in a purely juridical sense, a binding quality—but what is the practical sense of the recommendation?

WOLF: First of all, the governing body fixes the agenda, but the convention decides whether to make a convention or recommendation. At present we have 130 conventions, 134 recommendations. The distinction is essentially made so that matters can be dealt with through the convention system and are proper for the creation of multilateral obligations, and can take the form of a convention. There are certain details that could not go into a convention because the problems vary too much from one country to another. These details could prevent the ratification of the convention. They are not proper for the creation of international mediation, and therefore they go into a recommendation, supplementing a convention. There are other matters that are not dealt with in a convention; they may not yet be ripe for recommendation, but, at a later date, they may become the subject of a convention. Recommendations are essentially guidelines; conventions are matters that appear to be right and proper for the creation of multilateral obligations.

I should add that conventions that are not ratified in a particular country are nevertheless subject to our control machinery. That is, our control machinery can ask, from time to time, or can decide from time to time, to review the situation concerning conventions not ratified in certain countries; we may ask the various states what the situation is and to what extent has it been possible to implement the text, and what progress can be made to give it full effect. Whether or not the ILO conventions are ratified, the states bound by their ratification must report each year on the implementation of the convention.

SCHACHTER: Just a linguistic point for the record: the term "control," which you are using in the French sense, would be—

WOLF: Supervisory.

SCHACHTER: It really does have a different meaning.

MCDOUGAL: What I am trying to focus on is an attempt to use this method of achieving a world code within the mode of operating through the United Nations, through the General Assembly. In order to set it up, I would like to ask Mr. Wolf what other organizations affecting the environment could operate in this same way. Suppose we say we would like to get a world code on environmental problems using the ILO method. You can go a certain distance; the International Maritime Consultants' Organization could go a certain distance. Who else could go that distance?

WOLF: I spoke about a possible world environment code as a general idea, without having anything concrete in mind, at this stage. But what I meant is that part of the code probably already exists. Probably you would accept that part now.

To come back to coordination efforts: We have had joint meetings with IMCO on the Torrey Canyon case. Why have we come in? What is our interest? Immediately after the Torrey Canyon disaster we said we must do something about it. What we can do is study the extent of vocational training being given to the crew of the jumbo tankers to determine if the old vocational training is sufficient, is adequate. And we joined with IMCO in studying the various aspects.

On other questions—and I refer to another environment problem—we have engaged in a major program in which all the United Nations, as well as nearly all the other agencies, have taken part. This is our Indian program; the Indian government has shown that it could not solve the problem of those Indians who lived at 3,500 meters, are completely unproductive, and who die between 30 and 35 years old. We launched a program to bring them to a different environment, to bring them down to fertile valleys, with UNESCO to educate them, with FAO to show them how to cultivate the land, with the United Nations for general help, with WHO for all the problems of health.

MCDOUGAL: Who planned and directed it?

WOLF: The ILO initiated it, but there are other programs throughout the world that have been initiated by other organizations. On the question of who can help, I would say all the organizations: IMCO, UNESCO, FAO—

MCDOUGAL: Let us get them by resource. Who can work on the oceans?

SCHACHTER: You cannot really exclude anyone; everyone can work on the oceans.

MCDOUGAL: What about the air?

MCDOUGAL: But they can promote the making of conventions, not in the same way as the ILO, but they can take a comparable initiative.

SCHACHTER: I don't know that it is terribly important to go through a list. For one thing, all the agencies have expanding functions, and it is not particularly significant to pinpoint them in specific terms. The competence of the organizations would be more easily defined in terms of a series of problems rather than in terms of an environment.

KLINEBERG: Take the problem of human life. That is a very big problem, but the initiative came from the United Nations Economic and Social Council.

SCHACHTER: It came from the Charter.

KLINEBERG: But UNESCO was asked to play a major role, and I would say that many aspects of human rights concern the ILO and many concern the World Health Organization.

MCDOUGAL: I am trying to focus for the moment on environmental problems, how we will go about getting a world code, and who could take the initiative to get new conventions in that regard, and I think it would be useful to consider it by resources. Suppose we take energy resources. What organization could we go to? Atomic energy—I suppose it is clear, the United Nations and the Atomic Energy Agency.

SCHACHTER: In all these fields, there have been different kinds of organizations. I am not so sure this is a profitable line, but I could talk about it for a long, long time. There have been many situations with regard to energy, for example. A number of organizations have organized themselves into appropriate

forums, conferences, or other structures, so that the different aspects of energy were included when it was necessary to view the energy problem in a comprehensive way. So there are the Atomic Energy Agency, the Food and Agriculture Organization, UNESCO, because the United Nations took the lead.

MCDOUGAL: Is there any governmental organization concerned with petroleum? I know there are the private cartels, but is there any global organization?

SCHACHTER: There is a petroleum-exporting organization, and certainly much of their activity is on a global scale. The answer is not really in terms of the commodity, it is in terms of transport or production or some other aspects of it.

I want to raise another aspect of this question, which may relate to Professor McDougal's concerns, rather than to problems of competition between existing organizations. All these organizations have accordionlike capacity and can move with the problems and with the agreements. What strikes me as relevant—and and I am just throwing this in as the question of political issues—is that we lose sight of the fact that the key questions in environmental control will end up by being questions of who bears the cost. They will be the tough questions to settle. There will be informational questions and scientific questions, but when we are talking about the decision process, the issues will be very much in terms of the critical elements; can it be said, for example: "Don't have an Aswan Dam," or "don't have a Hindus River development," because it can now be seen that the Hindus River development is going to hit Pakistan hard, as, in fact, it has, or the Aswan Dam is no good? This kind of question will come up because of the vast amount of international funds flowing into these development projects.

Many of the points raised here I could not answer sensibly, because we are talking about an interrelated process of development, the United Nations Development Program, in which all these organizations take a part; issues of petroleum or future water problems will arise in a different context, not in terms of development projects, actions to be taken, and who bears their cost.

So, although the convention route has some importance—and I don't want to take a position on that—I am raising what I think is of far greater importance; this is a practical set of questions for the world community. What is going to happen to and with development, industrialization, and all the other actions that create the serious environmental problems? Should we have big tankers? Should we have water development? It may be a silly way to put it, but who will bear the cost? Who will decide? What will settle these issues? They will *not* be settled by a code, as far as I can see.

MCDOUGAL: The code might have some relevance to this. I would like to pursue this and put the question flatly: Would it be better to go to the General Assembly to get a comprehensive code?

CATLIN: One comment: Besides the fact of participation, there is a question of particular relevance to the World Academy; it is a question of professional organizations and the need to coordinate here for the strategy of getting the support of the professional organizations. That is very much our business and is extremely relevant.

MCDOUGAL: I apologize to the group, but because Dr. Schachter must leave tomorrow, and he is a fund of information about the United Nations, I would like to pursue him just a little more.

Oscar, I would like to get you to address yourself to the following, if you would: Suppose you took seriously the notion of a world code. Suppose a group of us decided we would like to get a declaration comparable to environment,

what would be the advantage of moving through the United Nations rather than through a series of specialized agencies, and how would we move through the United Nations?

SCHACHTER: Actually, it has already been agreed to have a declaration of principles. That is almost a nervous habit of the United Nations. They start everything that way. There is a working group on this, and at the last preparatory meeting of the Commission on the Stockholm Conference they divided up into two groups: one was a working party on this declaration of principles, which will eventually lead to sort of human-rights-declaration equivalents. This sort of thing has been going on for years. It is proposed that the Stockholm Conference, which will have a great many participants—all the organizations, all the people will be there in some way or another—will make this kind of general declaration.

MCDOUGAL: It will be brought back and put through the General Assembly?

SCHACHTER: Probably not. It is not necessary, because the Conference will be the whole thing, itself. And then—

CATLIN: There is then a working committee of the United Nations?

SCHACHTER: No, it is the Stockholm Conference, which is called by the United Nations, but in which all of the international organizations, and a great many other organizations, will participate through national bodies. And, there probably also will be proposals, conventions of a specific kind on specific problems. But this has not yet received general approval, and I could not predict whether it will be thought suitable for the Stockholm Conference. So, the Stockholm Conference will move ahead with these things, and the notion will take what I presume is now a fairly usual form, i.e., a code of relatively general principles, or if not general, they will be in terms like those of the Declaration of Human Rights, and then more concrete conventions that will include implementation machinery on particular subjects.

There are very controversial subjects. The tanker problem, for example—probably something can be done. But when you take something like pesticides, the idea that you could jump full-blown into regulation of pesticides through this kind of prohibitory convention seems unlikely.

CATLIN: Various regions are divided on their views.

SCHACHTER: Scientific knowledge will be divided. The predictions of what will happen if we eliminate pesticides from food production are controversial. There is no agreed policy. There is no clear judgment about stopping the use of pesticides. It is highly controversial and the kind of problem I referred to earlier: we must consider who is going to bear the losses. A lot of people will starve or in other ways suffer from such action. I do not expect that that kind of problem can be seriously dealt with in the short time of this conference. It requires more political bargaining, more of a flow of information, before we can move to something like that. The problem will always be about who bears the cost, and there is no use having these conventions unless you are going to get somebody to live up to them.

MCDOUGAL: The cost is more than the money; the cost is who is hurt.

SCHACHTER: That is what I am saying, and in very few of these cases will that issue be avoided. It is almost always the question of who is going to pay.

MCDOUGAL: Suppose you were asked to make recommendations to improve the intelligence and planning functions in relation to the environment. What would you recommend? Are there other alternatives?

SCHACHTER: I don't see them as alternatives. It seems to me you push ahead

on a number of fronts and try to build up resources. It would be better to get the professional organizations involved to the fullest extent, and that can probably be done by more specialized bodies than a total global body. That is why I do not endorse the notion that we will solve this problem by having an international agency. For example, on regional matters that call for specialized treatment, I think we will get better concentration of efforts if we approach it in this way rather than by having one comprehensive informational thing. For example, take the International Oceanographic Stations that are now being established under the International Oceanographic Commission: If the IOC had not been there and taken action, it would probably be years before anything were done thrown into a new general organization. But they are moving ahead with a setup for monitoring stations. I would like to see more of this specialized activity carried out.

WESTON: If I understand you correctly, you are saying that any effective control of environmental problems is going to proceed essentially on an *ad hoc* basis, depending on the nature of the problem that arises and focusing special agencies upon the problem.

SCHACHTER: That is not what I am saying. I am saying one can make decisions not in terms of problems but in terms of certain configurations that fit. The Arctic is not a problem; it is an area.

WESTON: Perhaps I used the wrong word. But in any event, whatever the configurations that you see it in terms of, and whatever the very specialized groups that will deal with those particular configurations, do you see any possibility of a more global assault toward the settlement of international investment disputes?

Would there be any kind of organizational construct that can be devised to authorize and make possible, for example, individual access to governmental and nongovernmental institutions or actions brought against governmental and nongovernmental institutions to enforce compliance with national and international regulations that may already exist or could be devised?

SCHACHTER: I think that is an important question. I don't think your example supports it, because it is an empty shell, and it shows the difficulty of setting up an elaborate structure, of putting in years of effort for something like that, and then nothing is going to happen. It is not a good way of dealing with investment disputes, in my opinion, and I think this is the same sort of problem.

I do, however, think there are, and I am not against, appropriate roles for global machinery. For example, I am actively involved in pushing the Stockholm Conference. That is global, and it will make a big bang. It is important to have a big bang at this point in order to win support and to move governments that have not moved; it is important also because it will raise issues and bring them into the view of governments that don't care about them. Most of the world does not care about environment; it is a rather limited excitement for the moment, which may soon die out. The reactions of a substantial body of opinion in the United Nations is that this whole movement is a threat to their development.

It is desirable to have certain broad issues of that kind discussed in a wide forum with many different voices being heard so I *am* in favor of global agencies. I think they can start things of a concrete kind. I don't think they can bring to bear the necessary interests, the necessary clout to a particular set of problems. As I said, I am not ready to list organizations that can do this, because they will have to be thought out in terms of specific issues, but the issue of whether you let people starve or you spoil the environment in some way is not going to be settled by organizational jurisdiction. Nor will it be settled by a code,

because the kind of thing you will get in a code is a provision that bank clerks are not supposed to work on Sunday. Everybody will agree to that, but, in this stage of concern for the environment you are very likely to get the kind of code that will say that one should not do something or other that will cause undue injury to someone else, or unreasonable losses, or deprivation, and this should not be imposed through the use of this or that. These codes have a limited value.

MCDOUGAL: What do you recommend that has substantial value?

SCHACHTER: I suppose everything I have said—and I have talked more than I should—has probably been along the lines of what I would recommend. I have recommended a whole series of things.

MCDOUGAL: To perform this intelligence function, would you have a new agency?

SCHACHTER: What intelligence function?

MCDOUGAL: That of learning more about the impact on man, anticipating a lot of these problems in advance, and clarifying policy about them.

SCHACHTER: I am not sure I would have *a* new agency. I would have many, many new agencies, which may be part of the existing organization or may not, but not a single new agency.

MCDOUGAL: What are the configurations of specialized interest or competence that you keep talking about?

SCHACHTER: I mentioned examples. I have mentioned regional examples.

MCDOUGAL: We want a relatively comprehensive picture of the whole thing.

SCHACHTER: I cannot give you that. In some cases there is a need to approach this in terms of ecological regions; that is one concept. In another case there is a need to approach it in terms of functions, for example, transportation of cargo, which may or may not be adequately taken care of. In other cases, it may be necessary to approach it in terms of personnel, that is, the professional people; what role will biologists or researchers in modern resources have? It is my opinion that although there are many organizations, these organizations need a great deal of development in these fields. You may need new units within existing organizations, or you may need brand-new organizations, as you probably would for ecological questions. This is not a question on which one can or should pontificate.

What I will pontificate on is what I would call "institutional poverty." We do not have enough institutions. This point of view is contrary to the view of all the rich governments paying the bills. It is an uphill fight, but you have to get them working on this. Having certain organizations on paper can be a snare and a delusion, because they will be paper organizations. You can have a global authority that will have only people who are so globalist that they will do nothing specific. They will just argue about admitting Red China, or something like that, and they will function only on that highly abstract level. So it seems to me that a great many things have to be done about the ways of getting support. I have mentioned these regional, functional aspects.

There is also an educational aspect. You have to have a network of inflow in the world of education; you have to build up institutions in many countries of the world to be sensitive to ecological or environmental problems. This function could not be handled in a monolithic way. You need many institutions to promote such educational activity. There are probably a couple of places where you can get more mileage, more impact, than in other places. For example, there is a great deal of international money going into development. Here you have an area of control. You can do something about that.

There is also a great deal of informational propaganda in this field now; there are a lot of scarce materials about how terrible it all is, et cetera. I suppose it is important to think now about the effect of all this hysteria about environment. This is an open question. People who were opposed to the Stockholm Conference—and they were swept aside by public opinion—argued that it would be bad, because a lot of hysteria or a lot of big words would be substituted for action. They said that we will drown the subject in a big meeting, which will make it seem as though something is happening, and all we will end up with is a lot of general language with no prospect of achieving anything. The British Government took that position. Then there was excitement back home about the environment, and they thought, how can you be against improving the environment? But their first position was that this is going to do more harm than good and, besides, would cost several million dollars that could better be spent on other things.

CATLIN: Wouldn't you agree? Call it environment. I like progress. Improve the environment; all men will bless you; you will have no critics. Once you come down to the particulars, quite specific resistances will arise; then you will have to consider what organizations, professional or otherwise, can handle that specific problem.

SCHACHTER: That is very much my line, but I would like to have people like Professor Catlin and Dr. Klineberg, two great authorities in their fields—politics and social psychology—discuss this. I am interested in the psychological aspects. What is the effect of all this hysteria? Where are we going with it, and what should we do about it?

KLINEBERG: I did want to say a word about what Dr. Schachter was discussing and to put a question to him. There is no doubt about the tremendous amount of activity going on in this field. UNESCO has a big program on "Man and his Environment." The International Social Science Council has a program chaired by a distinguished Japanese economist who recently got money from his government to hold quite a big meeting on this problem in Japan. I want to raise two questions, namely, is it within our purview to suggest a critical review of what is going on in this field from the point of view of what it is showing and, second, from the point of view of its influence?

I think that some information could be obtained with regard to both, but I just wonder. And here is where my question comes in: Is there any organization of the United Nations that is collecting information about all the things that are going on at the regional, national, and international levels in this area? There are very important psychological aspects. Somebody once put it this way: "We are all against pollution, but none of us are willing to give up the things that cause pollution." This is a psychological problem. Is that true? And how far is it true? Or, if people know about the influences of pollution, would they be willing to give up certain things? And if so, what? And the cost? I think there are some very interesting psychological or sociological problems in that area.

SCHACHTER: I would say the place or the forum or channel now is the Stockholm Conference, and the preparatory work for the Stockholm Conference. It seems to me that contributions can be made by almost anybody interested in this by having channeled into that Conference issues, questions, reflections, or anything else that bears on all these issues. That will be the great magnet. A lot of the work will be done in the next couple of years, before the Conference. The meeting is in 1972, but the preparation has already started. There is a great deal

of interest, for example, in case studies. Nobody knows very much about what has happened in the past: Why has the Indus project gone wrong? Why has the Aswan Dam project gone wrong? What could have been done to prevent the problems? A series of categories for which information is needed have been set up. How do you get people concerned in such a way that they will act reasonably rather than hysterically? How can you do this without causing more harm, which is far more of a concern in the United Nations than it is in Western Europe or the United States?

CATLIN: My understanding is that we are interested in what went wrong, and, according to Huxley, what went wrong was an excess of optimism and a lack of information.

KLINEBERG: There is another aspect. We were reminded that what is good for one country might not necessarily be good for another, and recently this question came up about the effects of productivity on the family, for example, and the problems of children's becoming educated when their parents were not, and what kind of conflicts are created in the homes. An Indian woman said, "You don't realize that for many countries in the world these things are unimportant compared with increasing productivity." So they do not want to be stopped or limited by some of these possible consequences, because for them the major goal at the present time—and I am not defending that goal, but I am generalizing from this report by one woman who said she cannot talk in those terms to the Indians, to the people who are involved in the five-year plans—is increased productivity, and that is what they feel they must have.

SCHACHTER: They don't care if the beaches are dirty.

KLINEBERG: Exactly. If they have to pay that price, they seem to be willing.

MCDOUGAL: What we need to know is whether you can help productivity without damage to the environment. Dirty beaches are inconsequential unless they carry disease.

CATLIN: On the specific point, there is a highly controversial issue of Ghandi versus anti-Ghandi.

MCDOUGAL: Let me put one more question. Suppose we try to improve the application of policies to particular instances. Who took this incremental approach that you recommended to deal with specific things? Are there ways of improving the applying processes? Would you recommend change in the court structures, new administrative boards, new procedures from foreign office to foreign office?

SCHACHTER: I would not mind seeing a technological ombudsman procedure on the international side or, as others have termed it, an international technological assessment board. Then there would be a question of how much we could do in the appropriate organization. For example, with respect to those resources that one would expect to be considered common assets, such as the ocean, I think we can reasonably expect and push for an international or multinational operation. It may not be global, but it may be a more specialized multinational operation. I suppose in such cases the analogy would be to an operating company rather than to a diplomatic conference.

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MCDOUGAL: Mr. Wolf, you do not have any special procedures for applications? You simply rely on internal procedures? Suppose your conventions are violated. How do you go about imposing them?

WOLF: The first thing is that we denounce the violation, and there is the full——

MCDOUGAL: The ILO denounces it?

WOLF: Yes, the supervisory body, which is composed essentially of two bodies, one expert committee, impartial, independent experts, and one tripartite committee at the conference, can denounce the violation. Any serious violation —in the eyes of those who supervise—is denounced at the general conference and gets the full pressure of public opinion, which is represented through the tripartite delegation of all the countries. In addition, there are contentious procedures.

KLINEBERG: Does that work better than the technique of condemnation of South Africa for its apartheid policy, which has just been ignored?

WOLF: True, the condemnation is being ignored, but the procedure being followed—which consists of reviewing, each year, the legislation of South Africa, to identify every thing that constitutes apartheid so far as employment is concerned, and the publication of our annual report—is useful. It does not help for the time being in South Africa, but at least it gives the world an objective, concrete image of what should be done to suppress apartheid on the contentious procedure. This has been successfully applied in the two cases that have been settled: one is the complaint by Ghana against Portugal for forced labor; and the other is the complaint of Portugal against Liberia on another forced-labor convention. Now there is a complaint against Greece on freedom of association. For the first two cases the reports that have been published have certainly clarified the position on strictly legal bases.

There are other procedures, too. Representations can be lodged by professional organizations, whether from the country concerned or from another country; finally we have the elaborate machinery that was established in agreement, together with the United Nations in 1950, exclusively concerning freedom of association; this applies even in cases of countries that have not ratified the freedom-of-association convention.

CATLIN: You are in a stronger position than the United Nations in a certain sense, because the United Nations is a judgment of sovereign nations, while in your tripartite structure, for example, if the employers move one way, the odds are the section would still keep the association going.

WOLF: I would not say we are in a stronger position; there we come into politics. I think the United Nations has a greater potential power for sanction.

SCHACHTER: I think the point is right. I share the view that we could get more out of this in the environmental field, if we got groups directly involved whose authority arises out of a professional position, perhaps, or a political position. This would be an objective to seek in the environmental field; there is an analogy with the ILO, although one would not have a tripartite system.

WOLF: Bring in the people, the community. That is the thing we tried to do in the World Employment Program.

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DROR: In terms of the Group's report, let me ask this question: Should we have something to the effect that we need to consider all approaches to all problems to make a reasonable decision? After all, the name of the scope is decision making.

MCDOUGAL: Would you formulate just a little more?

DROR: When dealing with all problems, including pollution, space, air,

population, all recommendations should be based on explicit analysis of alternatives. They should include a clarification of the policy, a statement of what is desired. They should pay attention to an explicit recommendation within a reasonably logical framework.

KLINEBERG: There is one problem that has been touched on that seems to me to be fundamental. Jan Tinbergen earlier discussed the relationship between national sovereignty and international programs. I believe Professor McDougal sees this in a quite opposite way. This whole question of where national sovereignty enters the picture, and what kind of problems——

MCDOUGAL: I think this distinction between national and international is an utterly false dichotomy. The problem is how you clarify your interests, including the interests you share with other countries, with other communities. I think in our description of this constitutive process we should say that this process is maintained by communities for the purposes of clarifying and implementing their common interest, which will include both exclusive and inclusive interest. This dichotomy between national and unnational is unworkable.

KLINEBERG: You are speaking like a very rational human being who sees the two groups of interests coinciding. But in terms of the way people see this—their perception of the situation—they may think that what is good for the international community may not be good for the nation. You may see that the two coincide. But the people who are involved may not.

MCDOUGAL: You misunderstand me. I am not saying there are not conflicts or a necessity for accommodation. What I am saying is that you may have to work this out in very great detail, but you cannot accept this kind of language approach; it is simply too confusing. And to talk continuously in terms of this dichotomy is diversionary. One thing we want to do is affect people's perceptions, and one of our tasks is to change these unreal perceptions and suggest other ways of seeing it.

CATLIN: May I suggest that there is language of definition, particularly nationally? There is confusion and lack of definition on such terms as "nationalism." It is important to bear in mind that there is a chauvinism, a tradition, but there also is, in terms of Ghandi, a tradition that is both nationalist and internationalist, and it has had tremendous effect and is worth bearing in mind.

MCDOUGAL: I think that before we get into the details of particular issues, we should reach a little more consensus as to what our objective is to be. What are we going to do, and what will we suggest?

SCHACHTER: I would support Professor Catlin's injunction that we ought to say what we should not do. I wonder whether this line is feasible—possibly it is appropriate—and whether it is really practicable to include dealing with the problem of war. I am not quite sure of what is manageable for this group.

It does seem to me we are going to have trouble dealing with the problem of war, as well as the problem of nationalism, as well as the problem of a decision process, as well as the problem of the environment, an international labor code, the international constitutive process. And although they may all be related, even a brief summary of a way to look at them may run to excessive length.

KLINEBERG: You mean they are all impossible, but some are more impossible than others?

SCHACHTER: If we are going to deal with the basic norms bearing on environmental problems, certainly we may have some formulations about coercion. But the question of war takes one quite a bit beyond that, and obviously

one does not deal with the question of war in a meaningful way simply by referring to Article II, paragraph 4 of the Charter.

LASSWELL: The important question is, to whom are we talking? At the end of this Conference we will want to have some policy-clarifying memorandum addressed, obviously, to the sponsors of the Conference, the American Section of the World Academy of Art and Science and the American Geographical Society. One of our goals here is the clarification of recommendations to them as to how they may proceed.

Proceed in what? Proceed in undertaking to increase the involvement of the scientific community in participation in policy processes, as they effect the popular emphasis on environment, but using that interest as a way to increase the concern for changing beneficially the decision process.

For example, it could be that one of the suggestions would be to increase the activity of the Fellows and Members of the World Academy in their various countries. The suggestion could be to mobilize initiative taken by these scientists, to make themselves available to the decision process of the country and region and to establish an identity, a liaison, perhaps, with the national or regional decision processes; perhaps they could likewise act as consultants to the youth groups if the youth groups become more active in more areas and wish to have some kind of consultation and guidance from specialists. This is an example of one of the activities that could be partially motivated. Likewise, the question: Should one address the United Nations or any of its component parts, indicating a liaison, a willingness to act as a scientific reservoir for whatever appropriate consultative activities that would be pertinent?

I mention these things only for the sake of indicating that if we do think in fairly concrete terms about to whom are we talking in the shorter range as well as the longer range, it might make it easier to decide how long a document to set up or how to handle the particular document suggested. We can include the idea of asking ourselves what we think about the present structure of the decision processes of the United Nations and of the other official and semi-official agencies. Do we have any suggestions to offer, stimulated by this functional analysis of how the definitions of intelligent appraisal, et cetera, can be performed? Are there any tentative suggestions that could be given better form and shape?

I gather that much discussion has been focused around the question of how can one offer a preliminary evaluation of a proposal for a new U.N. agency concerned with, or a declaration of principles concerned with, the global environment or the rights of man, environment, or however you wish to phrase it, and the designing of a strategy that would emphasize the potentials for territorial decentralization and pluralistic decentralization.

Do these remarks give a clue of any kind as to how we might think about the partitioning of the kind of documents that we would like to formulate in order to clarify the addressees, the immediate addressees, the second audience, the third audience, with respect to these matters?

MCDOUGAL: Let us test this out on the war thing. We purport to be clarifying ourselves here, making certain recommendations to the parent bodies about how they could set up further studies and be more influential. If we are going to make recommendations on how to set up studies, we have to formulate a problem and then bring in all kinds of people to work on it.

Which do we want? There are two different things involved. (1) Our own recommendations of the basic policy we would make to the larger community, and (2) Dr. Schachter's suggestion that we could not possibly do this in the time we have. I can put my own down in five minutes, but it might be that we could not get agreement. But if we take the question: How do we recommend to the parent body how to do this? then it is a very different thing.

CATLIN: I think I agree with Professor Lasswell. We have at the present time a general good will on the environmental question. Therefore, the first step is to state that and mobilize opinion behind these specific problems. And we have to carry out the need for close definition, and research in terms of the close definition.

WOLF: Couldn't we circumscribe the problems? I would just suggest five points: The first point would be to try—and we cannot do it here because we have no time and they are long studies, but I think we should lead the way and indicate that this is what is desirable—to circumscribe from our points of view, and more specifically from the lawyer's point of view, what are the environment problems. Everybody around the world talks about environment, but what is it? I see in the newspaper there are various initiatives being taken in this country, as well as in other countries. But I have seen nothing that could lead to a definition. It would have to be very flexible, because we do not know what will happen tomorrow. But at least the attention of responsible people should be directed toward a forum to circumscribe the problem of environment.

My second point is, again from the legal point of view, what is implied for us: humanity and peace, and I think this can be said now.

Third, what are the legal ways to tackle those problems? I mentioned earlier the fact that most of our international labor conventions are concerned with certain aspects of environment; certain of those conventions were directly concerned with problems of environment from the beginning.

My fourth point follows that: What means must be acquired, and what exist already?

Fifth point: What are the solutions? Again, I don't think we can, in a couple of days here, define the solutions, but perhaps we can briefly and flexibly indicate some of the points on which the solutions should concentrate. And the first should be to develop much greater solidarity among specialists of the various fields. Scientists go on in their field without paying any attention, most of the time, to the legal aspects of their work. Lawyers very often do the same. I think an appeal could be made from that point of view. We also need coordination of activities of all the bodies concerned, whether government, regional or international organizations, universities, research centers, and organizations such as professional employees' and workers' organizations.

And, finally, participation: Try to mobilize, to enlist the national community in the efforts that have to be made to fight the consequences for humanity of technological development.

MCDOUGAL: Very stimulating discussion.

KLINEBERG: I like the suggestion in a general way, but I would again raise the question as to whether, when we handle these issues, we relate them directly to the problem of environment and society or not. It seems that Mr. Wolf is suggesting a way of organizing material around the concept of the environment, and we would not be discussing war, as such, or even international cooperation, as such, but we would be discussing it in relationship to environmental problems.

If we divide on that, it will make our task, I think, rather simpler, and it will take care of Oscar Schachter's point about not trying to say what we

collectively think about war and peace in general. We would not need to, within the context of the problem of international cooperation in the field of environment, in the field of the solution of problems arising in the environment; I am inclined to buy that notion and not try, in this particular group and in the short time we have, to answer the broader question. I don't think we can say anything significant. In order to get agreement by everybody, we make it into a very real difficulty.

CATLIN: May I state my agreement with that? I think there should be a footnote or paragraph to state that this Academy has been concerned and is still concerned, but it is not our term of reference to this committee.

DROR: What we need is a logically analyzed breakdown of the problems.

MCDOUGAL: A comprehensive and homogeneous breakdown is what I want.

DROR: It could cause a lot of disagreement.

MCDOUGAL: I wonder if our sponsors are going to be satisfied if we limit our inquiry to generalities.

LASSWELL: The sponsors have defined the task in a way that has been influenced progressively by the growing popular concern for the word "environment."

Three or four years ago, when planning was first begun, there was much less public, articulate concern on the part of government and fewer demands concerning environmental problems. The original idea is reflected in the ambiguity of the title, "Environment and Society in Transition." In the intervening discussions, and notably at Stockholm last fall, the emphasis on the environment and man's relation to his environment led to an increase in emphasis on the environmental component, taking the rest for granted, but emphasizing the great importance of formulating policy objectives for man's continuing relationship to his environment.

We have audiences that are premobilized to be interested in undertaking to do something in the name of man's environment. The question is: Can we take advantage of this current interest in accomplishing these objectives, some of which are fairly clear, then shade off into the more ambiguous and more traditional objectives? Can we take advantage of this so that we are able, in effect, to say that here we are, with this increased concern for man's relationship to his environment? One of the outstanding consequences of this would be to emphasize the discrepancy between our decision-making institutions at the inclusive level and at the sublevel.

So one of our major problems is to consider the way in which our institutional process or constitutive process can be made more effective as an instrument for overcoming these environmental discrepancies. This means that one is in a position to say, after having formulated broad, general objectives, that among the alternatives open for action are suggestions as to the development of new machinery, new institutional changes that are global in scope.

After having linked up with the concern for environment in a somewhat limited sense, then one is able to go on and point out that, of course, if we think of our cultural tradition, of human beings as constituting our human environment, our cultural environment, it is quite clear that in our cultural environment our whole assumption is about violence; our expectations of violence are a continuing part of the environment that we are interested in modifying. This, among other things, moves explicitly to the consideration of the problems of abating the use of large-scale coercion in the processes of decision.

One way, then, of thinking about organizing the emphasis here is in terms

of some emphasis on objectives that are environmental; they, to a very considerable degree, are the physical components. Then, moving in terms of considering the improvement of decision processes and the improvement of the particular policy delivered by decision processes, we move to the task of bringing in the other matters in which we are interested.

So we go from the more particular concern with the environmental label to tie in that interest with all other significant interests in adapting the world decision process to something significant.

One other key point here is, who is talking? Obviously this is a group of scientists and scholars, and the problem is how can we clarify to the scientists how they can make themselves more effective in the process of transforming the institutional process as well as the delivery to the public of the decisions that are related to environment.

KLINEBERG: One little comment from a psychologist. I can see a very interesting transition from what looks like the more narrow emphasis to the broader emphasis. There has been a lot of psychological research that seems to indicate that when you can get groups to work together for the solution of a problem that is common to both, but in which each side depends on the other side, you can improve relations between the groups.

Could we, in part, urge the importance of getting all these things done on an international level, too, and then indicate the extent to which we can get the various nations of the world cooperating in the solving of common problems that cannot be solved unless they work together? To that extent we are making a contribution toward peaceful cooperation. There we could bring in the role of the scientist, the educator, and the others in bringing about that kind of change. Psychologists use a phrase, which you may or may not wish to use, "superordinate goals," i.e., goals that are common to two groups but that cannot be solved without the cooperation of both.

SCHACHTER: I would not disagree with that, but I have an important qualification. It seems to me that a great many of the serious problems that must be dealt with are not problems that, practically speaking, will be dealt with on an international level. If we are going to deal with problems of environment in society, I think we should recognize that many of the problems will have to be dealt with within nationalist societies. There is not much point in assuming all these problems in international terms; that is an occasional, infrequent aspect of it.

Certainly, as I see it, the hard issues that come up in pollution control and other environmental problems, will mostly be issues that will be faced within smaller communities—national, municipal—and therefore I think that the problem of this group should be much more comprehensive, concerned solely with the international level. While many of us are internationally oriented, I think it would skew the whole thing the wrong way.

WESTON: I have been wondering if I could clarify one thing, for myself. Professor's Dror's point, I think, is well taken—that the essential thing to be said is that a communication has to be made not only to ourselves but, as well, to the natural or physical scientists, of the need for very explicit clarification of their problems and how they can go about enlightening themselves as to how the problems they see can be more clearly articulated and, hopefully, resolved. I wonder, however, with this group, given not only time limitation but limitations on expertise about specific scientific questions, whether we can go much beyond that. Aren't we really saying that the kinds of recommendations we are

going to make are essentially methodological, as distinguished from what, for the sake of convenience, I might dub substantive?

LASSWELL: At the risk of unnecessary reiteration, let me remind you that among the things a conference of this kind wishes to produce are papers that have the following characteristics: Some recommendations for action, addressed to somebody, that are short. The rest of the policy preparation represents a method of mobilizing attention and acceptance of the recommendations. I reiterate this obvious point to the group here because might it not be part of the task of preparing a paper to present something that the Conference will be able to discuss and say, "Yes, we rather agree with that," or "We do not," and "Here is our preferred way of talking about that."

Have we forgotten to say anything useful to this scientific body about how members might act together to affect the decision and appraisal functions?

DROR: I have a question to ask about the formulation of the "meta" role. Do you prefer to make an effort to put the elemental pollution problems in a reasonable perspective or in a strong, sloganlike way? One does not want to speak about the assault on environment, the danger of survival; one wants to put this into perspective. It is a very important problem, but not the only important problem. It should be treated urgently, but it should not be implied that doom is surely around the corner.

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REPORT OF THE WORKING GROUP ON DECISION PROCESSES CONFLICT RESOLUTION AND THE CONTROL OF WAR THE ORGANIZED PLANET HUMAN RIGHTS AND INDIVIDUAL PARTICIPATION

Rapporteurs: Burns H. Weston, Francis Wolf

The very profound papers and comments that have been presented to this Conference have done much to delimit and clarify the problems that confront mankind in securing and protecting the earth's ecosystem. Many of the specific injuries to our natural environment, their causes, and their potential technical solutions have been outlined with precision and eloquence. Some of the more important general policies for the world community have been urged and explained with conviction and intensity.

It was the understanding of this Working Group that its principal responsibility was to recommend ways in which the world community might better organize itself for clarifying and implementing the common interests of all mankind in relation to the environmental problems that have concerned this Conference. The Working Group deemed it necessary, first, to account for some of the complex considerations that underlay the assignment and, second, to suggest some of the modalities by which mankind might be able to edge closer toward improved decision processes. A recommendation to the World Academy of Art and Science for a continuing commission of inquiry concluded its deliberations.

I

A. The Working Group notes at the outset that there is increasing awareness of the nature and urgency of ecological problems throughout much of the world (as in this Conference) and important public and private initiatives in many countries and at the international level (as in the scheduled 1972 Stockholm Conference on the Human Environment). But there has been little effort toward and less achievement of a comprehensive and homogeneous formulation of all the related problems concerning our natural environment that would readily facilitate the detailed clarification of relevant community policies, the description of past experience in the management of the problems involved, the study of the factors that have affected prior successes and failures, the projection of future conditions, and the invention and evaluation of appropriate solutions. The Working Group therefore recommends that all enlightened individuals and groups, such as have been represented at this Conference, continue to share their human and material resources at all public and private levels (from local to global) for the purpose of achieving a more precise and workable formulation of the cluster of interrelated problems that brought this Conference together.

B. The Working Group notes also that the basic community policies that relate to environmental and associated problems embrace both minimum order

(in the sense of the minimization of violence and coercion) and optimum order (in the sense of the greatest production and widest distribution of all values). The emerging aspiration of most of mankind is not so much for the mere conservation of some resources as for an effectively concerted and constructive employment of all resources in the greatest protection and widest distribution of all values. Peace is at stake, both in the major sense that people who are deprived of the basic values of life are inexorably driven to the use of force and in the minor sense that even weather resources, for example, may be employed for attack. Beyond the minimum goal of peace, the whole well-being, even survival, of peoples is fundamentally at stake. In addition to the better identification of specific environmental problems, therefore, there is urgent need for comprehensive and precise clarification, from a perspective that identifies with the whole of mankind, of the basic policies that can guide us to the solution of such problems.

C. The Working Group would note, however, that merely to detail the many problems of our environment, and even to clarify the general policies relevant to their solution, is only a beginning, albeit indispensable, toward the ecological planning, development, and control that are so desperately needed. The critical next steps include the identification and improvement of those processes of authoritative decision that can be made to contribute to the effective implementation of the common interests of the peoples of the world in securing and protecting the constructive enjoyment of their shared environmental base. In the opinion of the Working Group, the processes of decision that require modernization and adaptation in this vital connection are the basic constitutive processes of all of man's different interpenetrating communities, from local to global. Of course, some ecological problems may be economically managed at local or national levels. But when proper account is taken of the maze of interdependencies that prevail among both the organic and inorganic features of the natural environment and between such features and the institutions and practices by which man seeks to satisfy his many social, psychological, and bodily demands, the aggregate of problems is global in impact and thus requires global as well as local remedial measures. To be effective, improvement in decision process must therefore extend to the constitutive processes of all the component communities of the globe, as well as to the global order itself, with all sectors of participants objectively informed about and appropriately coöpted into the solution of the problems in issue at the local, national, and international levels. This effort requires the full support and assistance not only of governments but of university research centers, scientists and the representatives of professional societies, industrial organizations and other such nongovernmental groups.

D. The Working Group further notes that a remedial approach to man's natural environment that is global in scale, involving inquiry into all of man's interpenetrating processes of community decision, necessarily implies a conception of law—in particular, international law—that is more functional than structural in nature. Despite surviving popular myths that international law is not true law or there is very little international law, the Working Group finds that the world arena today exhibits a comprehensive constitutive process that, in its basic features, is comparable both in form and effect to the constitutive processes of our more mature national societies. This process—reflecting a fusion of authority with control (the appropriate reference of "law") that is to be found in the secular empirical expectations of community members about

who is to make what decisions, in respect of whom, in accordance with what criteria, and by what procedures—identifies appropriate decision makers, clarifies basic community policies, establishes necessary structures of authority, allocates bases of power for sanctioning purposes, specifies procedure for the making of various kinds of decisions, and secures performance of all the different decision functions necessary to the creation and maintenance of law (intelligence, promotion, prescription, invocation, application, termination, and appraisal). This is not to suggest that the existing global process of constitutive decision, or the governmental structures through which it operates, is today adequate to the task of securing man's basic goals in relation to his environment. The Working Group would insist, however, that we do have today considerable knowledge about, and skills in, the management of decision processes generally, and about our improving global constitutive process specifically, to be genuinely encouraged that more rational and efficient processes of authoritative decision can be constituted and managed for the better securing of basic environmental goals.

II

Recommendations for securing and maintaining our natural environment could be made with respect to every phase of global decision process: Principles and procedures could be designed for making participation in that process both more representative (ensuring that all who are affected by environmental decisions have a voice in making such decisions) and responsible (ensuring that all who affect community environmental policy are made subject to such policy). Clarifications could be sought to eliminate the simple-minded dichotomy between "national" and "international" interests, to demonstrate that the most enduring interests of any nation are the inclusive interests it shares with other communities. New structures of authority could be suggested for many different community levels, with appropriate openness in access and compulsory attendance for participants charged with transgression of community policy. For economy and specificity in illustration, however, the Working Group limits its suggestions for possible improvements to each of the seven decision functions mentioned above, primarily at the international level but with occasional supplementation at the national and local levels, and in relation to nongovernmental participation as well.

The Intelligence Function

The intelligence function comprises mainly the gathering, processing, and dissemination of information relevant to decision making. With the postwar proliferation of international governmental and nongovernmental organizations and the emergence of new techniques and technologies of observation and communication, this function holds a potential for truly massive inquiry into the causes and cures of environmental problems.

Recognizing that few of the many environmental perils that now face mankind can be adequately handled without facilitation of the performance of the intelligence function at all levels of social interaction, the Working Group recommends, as a matter of overriding general concern, the deliberate and

systematic undertaking of all measures that may be seen to enhance the efficiency, dependability, comprehensiveness, and availability of information and information processes pertinent to the clarification and understanding of ecological problems. In this general connection, the Working Group recommends that special attention be given to the fullest possible utilization and coordination of existing intelligence-serving techniques and technologies (e.g., polls, data banks, satellite observation), and, where appropriate, the creation and development of new intelligence-serving techniques and technologies.

Recognizing that existing services do not adequately serve the urgent need for information relevant to the establishment of a physically and psychologically habitable environment, the Working Group recommends, in particular:

—*at the international governmental level,* (a) the creation of new global and regional machinery with facilities, funding, and skills adequate for the comprehensive and dependable gathering, processing, and dissemination of ecological information, to be made freely and widely available to people everywhere, and (b) the strengthening of the intelligence functions of existing global and regional agencies that are charged with responsibility for given environmental problems through additional facilities, funding, and skills (e.g., the United Nations Secretariat and General Assembly organs, ILO, FAO, UNESCO, WHO, WMO, IAEA, ICAO, etc); and

—*at the national and local governmental levels,* (a) the improvement of existing environmental-information-gathering, processing, and dissemination functions of professional associations and research institutes specialized to the technical understanding of various aspects of the natural environment and, where appropriate, the creation of new such services, and (b) the widespread sharing of private ecological expertise with all other individuals and groups, public and private.

The Promotion Function

The promotion function comprises both simple recommendation and active advocacy and, as such, is designed to transform individual and group demands into authoritative community prescriptions. With the increasing availability and openness of specialized education, the burgeoning of contemporary communication media, and the rising democratization of participation in political processes, it is of course an operation of great significance to those who would protect the world's environment.

Recognizing the ease and skill with which environmental demands can be formulated and propagated and, therefore, the potential for harm, as well as good that inheres in the promotion process, the Working Group recommends, as a matter of overriding general concern, the promotion of common rather than special interests, the use of persuasive rather than coercive promotion strategies, and healthy skepticism rather than dogmatic conviction about the rationality of one's environmental proposals in the face of future unknown conditions.

Recognizing that mankind has but recently begun to awaken to the need for comprehensive and concerted ecological control and that, in any event, enlightened prescription (i.e., lawmaking) is largely dependent on enlightened promotion, the Working Group recommends, in particular:

—*at the international, national and local governmental levels,* (a) the improvement of existing agencies and, where appropriate, the creation of new machinery for the purpose of continuously re-evaluating and reporting on ecological information received, (b) the increased use of the mass media and other channels of communication for the purpose of mobilizing élite groups and broader audiences to a "world view" appreciation of the fundamental interdependencies of the earth's ecological system and of threats thereto, (c) the subsidization, coöption, and other encouragement of educational and research programs for the purpose of enlightening and mobilizing public opinion about the establishment and maintenance of a rational global environment, and (d) the wholehearted support by all interested parties at all levels of the 1972 Stockholm Conference on the Human Environment; and

—*at the nongovernmental level,* (a) the support of qualified specialists, research centers, and institutions of learning to devise new curricula, texts, and other educational tools that will foster greater citizen enlightenment about beneficial and injurious environmental use and practices, (b) opening, by the mass media and other channels of communication, of free time and space for the purpose of allowing concerned specialists and other qualified persons to influence élite and wider audiences regarding ecological problems, and (c) the self-mobilization of scientific and other professional associations, pressure groups, and political parties in attacks on environmental deterioration and in constructive recommendation of ameliorative practices.

The Prescription Function

Broadly put, the prescription function refers to lawmaking, to the designation of policies and the creation of expectations of authority and control that will sustain the policies designated. As such, it cuts across all institutional lines (i.e., legislatures, courts, administrative agencies, etc.) and includes even the outcomes of unorganized decision (i.e., "customary law").

Recognizing that individual and group willingness to comply with designated environmental policies is in large measure conditioned by the manner in which such policies are prescribed, it is of course essential that lawmaking about the environment itself conform to certain basic public-order goals. Accordingly, as a matter of overriding general concern, the Working Group recommends that all environmental policy formulations be comprehensive and contextual in their general or specific orientation, consistent with the basic goals of the plurilateral or bilateral community to which they are addressed, and effective in their communication of expectations of authority and control to target audiences.

Although there already exists substantial national legislation for dealing with environmental problems (e.g. conservation of natural resources, urbanization, etc.) and important international standards in this area (e.g. the conventions about the oceans and outer space and the ILO conventions on such matters as radiation protection, industrial safety and hygiene, underground work, etc.), clearly, many other prescriptions are needed to control overpopulation, the plundering of the earth's resources, and the precipitate mechanization of many of life's processes. Accordingly, the Working Group recommends, in *particular:*

—*at the international governmental level,* (a) the formulation and adoption of a set of environmental standards that might take the form of a World

Environment Code (perhaps including much of the above-mentioned and extant convention standards), setting forth policies carefully articulated to promote the world's physical and psychological environment, (b) the continued and accelerated use of the lawmaking machinery of the United Nations, its specialized agencies, and environmental conferences, including the 1972 Stockholm Conference on the Human Environment, for the purpose of achieving multilateral agreement and standardization on a variety of ecological problems, and (c) the adoption by all international organizations and conferences concerned with environmental protection of measures designed to stimulate responsive national legislation consistent with world ecological priorities;

—*at the national and local governmental levels*, (a) the formulation and adoption of comprehensive environmental legislation after due consultation with technical experts and qualified representatives of the national and international communities, and (b) the public encouragement of private rule making that will conform to basic community policies concerning the environment; and

—*at the nongovernmental level*, the formulation and adoption by private individuals and groups, of self-governing measures that will conform to basic community policies concerning the environment, thus creating expectations that will facilitate compliance with publicly prescribed environmental norms.

The Invocation Function

The invocation function concerns setting into motion authoritative processes of decision for the purpose of securing the application of community norms. Although some arenas remain closed to some claimants (as in the International Court of Justice to private persons, for example), most persons do have opportunity, either in personal or surrogate capacity, to complain about the violation of environmental protection prescriptions.

It is recognized on the one hand, that environmental assaults can affect most grievously the life of every human being and, on the other, that the efficient administration of justice may sometimes require limitations on jurisdictional access, and it is apparent that an appropriate balance must be struck among the policies that regulate the invocation function. Accordingly, as a matter of general overriding concern, the Working Group recommends that the extent to which claimants may be authorized access should be determined by reference to context, that there should be a presumption of free access whenever and wherever possible, and that, in any event, where access is authorized, prompt sanctions should be applied to avoid irremedial deprivations.

Recognizing, however, that there remains an overwhelming need to hold environmental violators publicly accountable, the Working Group recommends, in particular:

—*at the national and local governmental levels*, (a) the fostering of free and direct access, to the widest extent possible, for all environmentally damaged individuals and groups, to impartial judicial and quasi-judicial arenas of decision under procedures comparable to existing international and regional human rights mechanisms, and (b) the establishment of an environmental ombudsman under the auspices of the United Nations to whom access may be had irrespective of United Nations membership;

—*at the national and local governmental levels*, (a) the fostering of free and direct access to the widest extent possible for all environmentally damaged individuals and groups to all national and subnational processes of decision, (b) the establishment of environmental ombudsmen (or commissions of inquiry) at all levels of national life, and (c) the encouragement and safeguarding of all noncoercive forms of expression for protest against violations of national and local environmental protection policies; and

—*at the nongovernmental level*, (a) the coordination of efforts by individuals, private associations, and pressure groups in their invocation of national and local environmental protection policies and (b) the establishment of procedures requiring that the management of private associations (particularly those engaged in commerce and industry) be held accountable to their memberships for the violation of community environmental policies.

The Application Function

Broadly put, the application function refers to law enforcement; that is, to the transformation of authoritatively prescribed policies into controlling events. As such, like the prescription function, which it closely parallels, it cuts across all institutional lines (legislatures, courts, administrative agencies, etc.) and similarly includes even the outcomes of unorganized decision ("customary law").

Recognizing that the full—even partial—realization of environmental policies, not to mention public confidence in the legal process itself, is fundamentally dependent on the successful enforcement of prescribed community norms, again we must be concerned for the promotion of basic constitutive policies. Accordingly, as a matter of overriding general concern, the Working Group recommends that the application process be prompt and efficient in initiation and resolution, comprehensive and realistic in its specific orientation, and constructive and consistent in its final conclusions.

Recognizing that international enforcement of environmental policies is probably more effective today than is commonly realized and that, until recently, national and local enforcement of environmental policies probably has been less effective than is popularly believed, the Working Group feels that it is nonetheless self-evident that there is need for much improvement in the processes of norm application at all levels of social interaction. Accordingly, the Working Group recommends, in particular:

—*at the international governmental level* (organized arenas), (a) the consideration of specialized adjudicative machinery regionally and functionally environmental in focus and, in any event, technically qualified, interdisciplinary, cross-culturally representative, and open to direct access by private individuals and groups (paralleling, for example, the World Bank's new Centre for the Settlement of International Investment Disputes), (b) the repeal of those restrictions, such as the Connolly Amendment, which make the International Court of Justice and other adjudicative bodies virtually powerless to resolve environmental controversies, and (c) the adoption, wherever feasible, of compulsory arbitration procedures in ways that are compatible with the "conciliation" arrangements set forth in the recent Draft Convention on the Law of Treaties;

—*at the international governmental level* (unorganized arenas), greater

democratization of foreign-office-to-foreign-office procedures aimed at resolving environmental conflicts and, in any event, an increase in technically qualified and interdisciplinary foreign office staffing;

—*at the national and local governmental levels*, (a) wider use of expert witnesses, court-appointed masters, and technically equipped bodies specialized in the resolution of environmental conflicts and (b) the highest possible coordination of applicative procedures and programs between and among national and subnational governments and agencies; and

—*at the nongovernmental level*, the encouragement of individuals and private associations, particularly those engaged in commerce and industry, to make explicit how and to what degree they will comply with, and assure adherence to, community environmental policies.

The Termination Function

The termination function puts an end to prescriptions and to arrangements under prescriptions when they have ceased to serve their purpose or have become inequitable. In general, the termination function is performed in the same structures and by the same procedures as the prescription function. Occasionally however, there is resort to unilateral decision, sometimes even by naked power, with special deprivation of some parties. Hence, ameliorating the attendant losses is a unique problem of termination for which provision must be made.

The importance of the termination function at the international level is especially evident because of the relative absence of prescriptive organs. During the past 25 years it has been performed mainly by the General Assembly of the United Nations, as is demonstrated by the great number of territorial communities that, with the help of the United Nations, have been released from prior arrangements. The Working Group would recommend continued resort to the United Nations and, in general, recourse to the same structures of authority and to the same procedures that were recommended for the prescription function whenever environmental crises may so require.

At the national level, the Working Group recommends, again, recourse to the same structures of authority and to the same procedures that were recommended for the prescription function and, by these devices, to put an end to arrangements that may be seen as detrimental to environmental protection.

The Appraisal Function

The appraisal function monitors and evaluates past decision processes in terms of the degree to which in fact they secure the community goals for which they have been established. It is thus a part, but a very specialized part, of the intelligence function first mentioned, which permits an audit of the success and failures of past practices in realizing perceived goals.

Recognizing that international and national environmental policies are certain not to succeed without the undertaking of the appraisal function, the Working Group recommends: (a) the establishment and maintenance of self-monitoring and self-appraisal systems on a continuous basis by all international and, national organizations and bodies that deal with environmental problems and (b) the establishment of outside monitoring and appraisal systems comprised of qualified experts charged with the responsibility of periodically reviewing the progress made by all organizations and bodies in quest of ecological protection.

Continuing Commission for Inquiry

The recommendations hereinabove made are obviously only illustrative and tentative. An immense amount of work by specialists from many disciplines would be required to make them otherwise.

Among the commissions for inquiry that the World Academy of Art and Science might establish in relation to environmental and associated problems, one should be specialized to decision processes. Such a commission should be interdisciplinarily holistic in character and establish necessary liaison with all the more important governmental and nongovernmental bodies concerned with the general problems under investigation.

Working Group

ECONOMIC AND SOCIAL POLICY *

Chairman: Alexander King

Participants: Lester Brown, Josué de Castro, R. Buckminster Fuller, Hasan Ozbekan, Mrs. K. Crouse Parry, Aurelio Peccei

KING: For those who weren't present at the last session, we began with a rather drab discussion of the possible effect of the market mechanism in relation to the socioeconomic problems we are facing. I think there was eventually a gradual revolt against this focus, because our situation, with its complexity and its artificiality, and the alienation of the individual in society, the lack of motivation, the rigidity of organizations, the depressing effect of bureaucracy—all this means that we cannot merely recommend small changes in our existing situation. In fact, we feel that discontinuities must take place in social development from time to time, and they may be associated with revolutions. They may be possible in the aftermath of war, or they may occur by other means, but something basic is required now.

A number of us have taken up a rather synthesizing, integrating, systematic approach toward the totality of world problems. We had a debate with the lawyers,† or a semidebate, that was a conflict over the idea of how you progress from the present; some suggested modification of our present institutions, marginal techniques that most of us here reject as not being useful.

The alternative was a normative approach—looking at the interaction of world problems and taking a period, say, 1990, that is near enough to be of interest to us, although probably a little too near for it to be possible for us to do much about, but at any rate taking a generally utopian view of what we would like the world to be like in 1990, and then seeing how it could gradually be achieved. We are now ready to look at a number of problems in human values, the value of the human individual, the changing values, the diversity in the integrated approach, and, at the same time, we could begin to suggest an institutional approach. Inevitably, this will sound horribly utopian to some of our lawyer friends, as well as to others, but we still feel we would rather go forward in this way than in a more pedestrian traditional socioeconomic manner. Somehow, we have to work in terms of a global systemic approach.

PECCEI: Yes, we should not be making a number of different documentary proposals of visions for utopias; our suggestions should be understood as proposals, although not for this very day; probably our proposals will require further study, and they should be built into a system. That is, they must be consistent with each other. We may also consider the means—if there are any—to keep that system together and build from this one to that one.

* Only one brief session of the deliberations of this working group was transcribed by the stenotypist, and, as a result, much valuable material was lost.

† See "Combined meeting of The Working Group on Decision Processes and the Working Group on Economic and Social Processes," page 602.

What we have to do first is jump into the future, abandon the constrictions of today's situation. We must do this as reasonable people, not totally idealistic, but people who understand and are realistic about the difficulties of this world. We make this jump to 1990, beyond the reach of the present democratic political parties or European structures, beyond even concepts of underdevelopment, to plan freely, plan it with a certain number of population and resources, with a certain history. We obliterate a small fragment of history in the 20 years from 1970 to 1990.

To design the world of 1990, we know that there are limitations in human biology, in human minds, in resources, capacities; there are built-in constraints, but we should not add man-made constraints and hinder ourselves. If we would design that world—neither too far away nor too near—we must consider carefully the kind of world we desire; then we will see if our design is compatible with many other things.

OZBEKHAN: I propose that we approach this problem in a manner that would go beyond what now seems to be merely goodwill words by stipulating the necessity for a new theoretical base upon which to found and ground our general vision. Two fundamental approaches must be adopted, I believe. Number one is that in order to build a theoretical base, we have to construct an ethic; one of the greatest troubles with our current age and institutions is that the ethical foundations of our vision have become obliterated. The second approach is the more structural, the more methodological one. I have always proposed that we conceive of our vision and of our future in relation to our situation through the formulations that have been emerging for the last few years in general systems theory.

Insofar as our report is concerned, therefore, we have to stipulate somewhat in its germ structural forms the systemic characteristics, not only of the situation in which we live, but of this situation as something that we have entered and which is going to be more of this kind, rather than less. The situation has some fundamental characteristics from the systems viewpoint, namely, that every occurrence becomes, even the most fundamentally technological one, increasingly ephemeralized, increasingly nontangible. This is an immense new emergence factor that will, in fact, dictate some aspects of our vision of the future.

The second thing is that reality is more and more beginning to appear not in terms of things, which has been the great achievement of 19th-century philosophy, of positivism, to show us that reality was made up of just supposed things, but rather as flows within which the things are defined as those elements of the flows that, over time, keep their structure.

KING: And very often instantaneous events?

OZBEKHAN: Yes. I will come back to that.

The other aspect of the system that is of great importance is that events occur within it, and because of the greater flow of realization that exists in the system, and because of the greater ephemeralization of events, events have become acausal in a sense that has two meanings. One meaning is that an event affects the whole system almost immediately, and it goes immediately to the boundaries of the system. The second meaning is that you can no longer define the direct cause-effect relationships that have given birth to the event. Hence, we live in a reality that is acausal, flowing, and in which objects are, therefore, growing more and more ephemeral, and increasingly we live in an evolutionary reality in which what we call "information" is replacing what

we have called "technology." Information is a concept that you can widen to encompass a great many points.

The other very interesting phenomenon, which explains a little our situation today, is that events do seem to follow something that the biologists have noticed in evolutionary theory, namely, they are not continuities, but they are jumps. Once we recognize that we live in a situation in which what we call "evolutionary processes" jump rather than continuously evolve, something very interesting happens: We begin to understand why we are confronted with a great deal of misunderstanding. It is for the simple reason that when you are in a reality in which the evolutionary process jumps, you have no organisms, you have not established any institutions, you have no mechanisms through which you can communicate the perceptions of the higher level of the jump to an existing world. Consequently, what we have to do, in fact, is to push the jump to its logical conclusion and to define what we call "future" in those terms.

Everything that I have talked about until this present moment represents, in some sense, a biophysical, theoretical base, for the phenomena with which we deal, including economic and social phenomena. By the way, the application of these is very interesting and very easy. The thing that is missing is precisely the human element into which this has to be introduced, and which is what I call the ethic. The ethic is that which gives us our vector of growth, our direction of vision, within a world conceived in this event-jump fashion. If we don't have the ethic, we're not going to be able to give any kind of direction in any way to these occurrences. An ethos manifests itself, aside from some extremely firm and primitive foundations, by certain statements of values. An ethic is always basically the definition of the good in the light of a new situation.

Hence, in order to be able to develop a vision of the world in which the transition discontinuities and the transitional pains of our age have been taken care of, we have to create an image of the future that is based on a particular definition of the notion of good. If this notion of good has been communicated and can be communicated to the people around us, then there is a chance that it is possible to develop the institutions and instrumentalities that, optimally, can bring about that particular good.

Let me also explain that this is an extraordinarily difficult exercise to achieve, for the simple reason that basically we have to do it without having a language for doing it, because our languages generally are symbolic representations of the situation as it is today. Hence, there is a new meaning that we must aim at in communicating with a language that doesn't fit the situation we want to describe. I believe we must go into these questions in order to be able to give specific meanings to things with full consciousness of the ethic, et cetera, educational or scientific knowledge, or love, or community, or collective absolute. We must understand what meanings and weights we ascribe and what modalities we work from when we talk about things like markets, taking an economic term, or pluralism, taking a socio-political term, or democracy and participation, or income distribution or employment or development. Unless we go through that exercise, everything we say will remain meaningless.

Unless we are able to identify full dimensions, every picture we create will be two-dimensional, will be just the words of today applied to a situation that doesn't exist, and therefore must be considered as clichés because the words of today, applied to a situation that doesn't exist, in fact, become clichés.

PECCEI: You are convinced that we have to use, unluckily, our present language to define present words applied to a future, unknown situation. That is, we have to make a metalinguistic effort.

OZBEKHAN: Create a language to understand language.

PECCEI: A symbolism.

OZBEKHAN: Not necessarily symbolism.

PECCEI: Iconography, a means of communication or expression.

OZBEKHAN: These things happen in the course of evolutionary processes in society, in any case. For instance, what the 19th century used to call technology represents a very different experience from what we call technology. Buckminster Fuller is a man who all his life created new concepts and new words precisely in order to give meaning to a reality that people were trying to interpret in terms of words they had inherited from their parents. Maybe you would like to say a few thing about that.

FULLER: I would very much. Physics was founded on no solids, no continuance, only on energy events; there are obviously no things, and therefore there are no nouns. We have to talk in verbs, and only verbs. I have spent a great deal of my life trying to discipline myself into this verbing. In relation to Marx, for instance, it is very exciting to realize that Marx accepted the data of Malthus as the first economist to take vital statistics from a total system effort as against what we were all brought up on, empires as going to infinity. But the first time that it was in the public domain that the earth was a sphere, with open systems, empires, there was an infinite number of variables, and if you didn't like what was going on you could get the infinite number of "gonads" together, and you could come out all right.

If we didn't like what was going on, we had a great deal of hope with an infinite number of variables. But we were not brought up at all on that, because with a closed system there is no longer an infinite number of values. What was really important about Malthus' findings was that his were the first data from a closed system. He found that man apparently was reproducing himself at a geometric rate and producing goods at only an arithmetic rate, and therefore man was destined to failure.

We have a Darwin, among many biologists and geologists, who, taking a view of things enclosed by masses of ocean, took a look at what resources could then be exploited. The closed system is linked to all kinds of living species. Darwin could not have evolved a theory of evolution in the Roman Empire because he would have had to include other things. You can't have a general system until it is closed. We were never given that differentiation. It is not really the general way of looking at things. At this point Darwin was explaining his evolution, survival of the fittest, and we have two scientists who apparently have discovered that man is doomed to be a failure, and survival of the fittest should include the right to live.

All the lands were separate, and thinking of the land was very limiting. But a water man thought of the whole show. He thought spontaneously in systems, whereas the people in the land did not. The great masses on that ocean said, "We are the best-informed. We have all the fighting tools in our hands. We are obviously, then, the fittest." We have, then, Karl Marx encountering both Malthus and Darwin and agreeing that there is not really

enough around. They said clearly to him that people on the land who did the work and who have the know-how to work the ground were obviously the fittest and the other people were parasites. These are the two extremes that have been applied to all of our thinking.

When Marx began to talk about class warfare, there seemed to be really two species, a dumb people who didn't have the right reflexes and could do simple things, like tending the sheep and handling the chisel, and didn't have to have literacy in order to do them. Marx assumed this to be so, and he called it class warfare, even with two really quite different genetic species. I think this idea has been carried on. There are many who are idealists and say that this is unfair. The trouble is, this is a very dark and accepted fact. Marx said that the duller man has to have very simple rules to go on. His standards of living would be very low.

It is only within the last five years that we have had scientific proof that malnutrition during gestation of the child and the first two years damages the brain and that what has really been considered a genetic group was simply impaired by faulty nutrition. I think it is absolutely clear, all of a sudden, that suddenly there are a great many brighter people than we thought, and we have a very bright young world appearing. It would be typical that you find the class concept is suddenly scientifically obsolete.

OZBEKHAN: Yes.

FULLER: I am supporting all your statements, but I would also go along with your quantum leaps and discontinuity and complete abandonment of linear thinking, because we have omnidirectional convergence and divergence of fundamentals of our universe. Everything you say appeals to me, but I think we must be seeking language, and we are able to accommodate it, to some extent, by using a few more words. We do not have to break out in a completely new dictionary.

My work in almost the last 50 years has been predicated on the kind of assumptions you are all putting forth. I have lost myself in thinking nationalistically or as an individual. I am part, really, of a great complex, and we have to understand something bigger. I started working in terms of our total earth. National resources have been unevenly distributed. We try to see what the total system looks like and how we might best employ the resources. This brought me to a vigorous consideration. I began to study the total resources, and total people and total needs. This was influenced at the time I came out of the Navy in the transition after World War I, really a very high state of technology from an earlier type of Navy, where all of our older officers and all petty officers in the Naval Academy were all sailing-ship men and not only did not believe in steam but did not believe in the new kind of automatic turbines, which are very different from coal stoking. Suddenly we had electronics and things like the airplane. We were doing the most highly classified of all matters in the Navy: Who was going to run the world? The man who could have higher tonnage could produce greater hitting power, delivered a little farther away, with greater accuracy, and would win. You had something you didn't have on the land, where things could be heavier. On the sea you started with a given weight, and those who could do the most with the least would win. By far the most highly classified of all secrets was that people around the world were doing more with less to such an extent that the fact is not in a book on economics on the subject. There is not

even a chapter in a book on economics, not a sentence in a book on economics, about doing more with less.

Today it is very evident to the new world that miniaturization, going from bigger to smaller, is familiar, but it was not familiar to our society at that time. The technological revolution by 1990 will be great. If one decided to have a showdown, it would take another resultant structure. That is how long it takes to build an entirely new kind of technological relationship. The picture of the masters, the resources very unevenly distributed, was taken from the Orient. The skills of the Orient, the riches accumulated there, were profound. Even as late as our coming into World War II, the man in China or India was getting more. I have been building domes around the world, and I use metal workers. India still has the best metal workers in the world. They are the highest-paid people in India today. I could take any one of those metal workers to Detroit and get him a job as a toolmaker, and he would then make in one week more than he makes in a whole year in India. This is the foundation of industry. East is East and West is West, and never the twain shall meet. And so you have the longest kind of cash-in route from one obscure place to another. The intent is that the other will never catch on to how it is being cheated.

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FULLER: I am deeply impressed with the universe and the generalized principles we begin to find operative in universes. I see man as very vain in feeling it is up to him to run things. We begin to get down to the size of our earth as 8,000 miles in diameter, and the nearest star is 92 million miles away. Here is this little speck, and the people on it think they're running the universe. The cosmic forces are looking out for man a great deal; I see man as born utterly helpless, with beautiful equipment, but absolutely ignorant. I don't think it is derogatory to recognize that he is very ignorant. Utter helplessness can be taken care of; older people feel this way about the child. All these things have, *a priori*, been provided. But I also observe how life was designed and I am deeply impressed with the total equipment and all the regenerative capabilities of life and the world ecology. I see each child, and it does begin to coordinate and take on information. I think our society is beginning to get in a position where there is room for responsibility.

And so we come to Dr. Ozbekhan's ethic. I think we are at that crisis. I think that our young people are beginning to see the dawning of an age of very high ethical sense, and they cannot stand hypocrisy or lies any more. They are trying to get out from under. They have not much experience to go on yet, but I think we are at that kind of breakthrough point of seeing everything you have mentioned take form, and I am very much in favor of it.

I was seven years old when the first automobile appeared in Boston, and so I was brought up with the horse and the bicycle and the railroad. Our telephone was number 10 in the complex. Communication then was so slow that there was a man in our town who had been to Europe and had to give a talk every year about his trip to Europe. People in the next town were supposed to be dangerous brigands. The isolation of America was very, very great. Now we are suddenly at the point where our young world is literally getting total information from around the world, visually, and it is occurring in about one-twentieth of a second. We have, then, a completely new set of

conditions. When you talked about making a model airplane, your parents would say that it is inherently impossible for people to fly. There was no radio.

KING: Socially we still think that way.

FULLER: I grew up with a great amount of information given to me with great love, in the hope it would help me. I have spent a great part of my life unlearning all the things I learned, which is part of the language we speak about. I would point out that each child who is born is now being born in the presence of less misinformation, and in the presence of a great deal more reliable information. When I was young we were trained to behave properly when the boss's wife went by, to say "Thank you," to hold our knife a certain way, or people would think we didn't have any manners. You feel it is the people who love you most who are teaching you, and you learn to tell white lies.

Then the lies get bigger. And we get to where man gets rather unscrupulous and tells fantastic lies. It is a sad fact that in the business world you are confronted with lies time and time again, sometimes disastrous lies. It is a matter of survival, and you feel if you're going to survive you might as well lie; it is better than using a gun. There is that kind of rationalization. And so the lying becomes prodigious. We went out from school assuming that the society is only telling lies and we were going to have to get into that kind of thing, which we didn't like.

I am telling you this because today we have found out that so much is not true; we think that telling the truth is very difficult and that telling a lie is easy. I point out that every child tells the truth, spontaneously. I think that lies are superimposed. My greatest hope is for the construction of an ethic. I want to emphasize what was said about ephemeralization. Anything ethical is going to affect all of our lives and will be conducted, today, in the realm of unreality, where man cannot see, smell, touch, and hear. We have contact only through instruments. You know where all the resources are. That information is in this room. This is the reality that we are not catching onto.

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OZBEKHAN: Within the framework we have talked about, the feeling of reality we have talked about, let us now discuss briefly some goals that are possible—or even impossible. It doesn't really matter, because the whole notion of possibility is quite irrelevant. And in considering the particular subject of this Working Group, we can go on to say that certain institutions have to be fully reshaped and restructured, or created or invented, in ways about which we have no idea today; at least, nobody that we know of has worked on it. For instance, we could approach this problem from the viewpoint of information technology alone and rewrite the whole of economics entirely. It doesn't explain reality in the least. Then probably we could make certain noises about the difference in intensity that the problems have in the world environment as a whole; for instance, we are forever talking of development of the underdeveloped countries, but we really are trying to impose on them, through that "development," our mistakes of the last century.

Basically, of course, we haven't done such a good sales job: the underdeveloped countries insist on committing for themselves all the mistakes that we committed.

KING: Even to importing our outmoded educational system.

PECCEI: That is kind of a joke.

OZBEKHAN: It is true in some fundamental sense.

KING: We're talking only about our mistakes, but a great deal of material advances have gone along with the mistakes.

OZBEKHAN: About our statement—I believe that the human right to a share of the wealth and production, not because you work, but because you are a human being, is an absolute, fundamental requirement for such a statement. There are no two ways about it.

KING: I firmly agree.

OZBEKHAN: From this derives a picture of the production pattern of the world, namely, that production ought to occur where it is most optimally productive, and with geographic distribution of all production. This is also fundamental. But it is impossible to do all this without new forms of political organization on many levels, which go beyond today's nationality concept. I think this may go as far as the question of the withering away of the state and abolition of national sovereignty in some sense.

PECCEI: Also, in the concept that sovereignty is now state or national or individual.

OZBEKHAN: Then comes the question of control of world population. This is a major problem, because none of the previous things that we have discussed can occur if the world's population is not somehow controlled. The most difficult point in all this becomes the cultural-ethnic differentiation as against diversity. Diversity, obviously, we want to keep. Whether differentiation can be kept in such a system, I don't know.

KING: That is one of the big question marks.

OZBEKHAN: Everybody is very much in love with the fact that because our cultures have been differentiated, and we found certain enrichment in that differentiation, it should necessarily continue. Whether that is feasible within such a picture as we have talked about, I don't know. Diversity of individuals and full opportunity for individual diversity to develop, yes, but—

KING: But not necessarily geographically.

OZBEKHAN: But that we can adhere to cultural differentiation—and by that I include linguistic differentiation—I do not believe.

PECCEI: There are many people who are bilingual, so there might be a lingua franca. With regard to cultural differentiation, you say you cannot visualize, or you doubt how this could fit into that kind of world. One can also say the opposite. Could that kind of world not allow cultural differentiation?

OZBEKHAN: We have to understand what cultural differentiation means. Basically, as Dr. de Castro has said, there are different modes of adapting to the environment. If the world environment becomes one, the different modalities of adaptation will diminish in various intensities.

PECCEI: There is a scale.

DE CASTRO: It will never become one. The basic and fundamental natural conditions are quite different.

PECCEI: The poles and the equator are different.

OZBEKHAN: But there is the other point—that cultural differentiation also refers to the ethic; adaptation to differences in environment also brings different definitions of the nature of the good. A greater homogenization of the environment will tend to erase those differentiations in the interpretation of what is good.

FULLER: That is the greater trend, too.

PECCEI: That homogenization is one that will have median values of difference. It will not be a unique one.

OZBEKHAN: It will probably not be a unique one, certainly not by 1990. But the reason I am harping on this question is that unless this is recognized, and unless we free ourselves of the very emotional and romantic idea that cultural differences are beautiful things we have to uphold—because cultural differences are what made wars and are what set people against each other, and so on, and unless we clarify that point, none of the other objectives can be obtained.

FULLER: I have traveled around the world, and I have visited 260 universities. The percentage of what are called foreign students is going up so very rapidly that I would say the young world has got to the point where it is obvious you don't know where you go; you just go. You are a world man, and that is all. The only thing that really militates against this are some of the very severe curtains. Otherwise, they would be homogenizing very rapidly.

DE CASTRO: I would like to ask if it would be necessary or adequate to write something about the problem of war and disarmament?

OZBEKHAN: It is very necessary.

DE CASTRO: Even in the United Nations, and I say "even in the United Nations" because even conservative bodies admit today that they cannot have "the decade for development" without "the decade for disarmament." We must insist on both. It seems to me if we don't consider the problem, and if we don't make some recommendations—we must insist with governments, especially the great powers, that international security depends much more on the world's economic needs than on atomic arms—then we are not doing what we should.

OZBEKHAN: I agree.

PECCEI: I agree.

KING: I think we come to it logically in our presentation, because we have discussed the right of everyone to have a minimum.

PECCEI: I would like to say something about war. I am deadly against it, of course. It is the cancer of everything. But we say that there should be a political organization, probably with a world authority and regional authority that, per se, preempts the concepts of war among state-nations, but it is an organization that is conceived in terms of war. There might be civil war; there might be revolution; but we are speaking of the war of the military, which is now going on. There might be war between police and citizens, but not a war between armies, between states.

KING: Between professional armies.

DE CASTRO: If we don't underline the economic implications of war and the effects war has, we cannot have a solution on a world level.

PECCEI: It is the same thing as saying that we will not have diversity because people are equal. There can be no war because there is no juridical individual who can make war.

FULLER: At the present time, those who have the tools capable of making war are relatively few in number. Unfortunately, all the war that is going on now is supplied by those two or three. As I talked to individual Arabs or Israelis, and as I traveled those countries, I found that the individuals feel they are very much put upon by the politicos. The only reason war is going on in the Mid-East is petroleum: who will get that oil?

To talk about disarmament, you really must talk about very few. I have been at several meetings between the Russian and American groups, because

Norman Cousins and I met with the scientists and the military. I am quite convinced that the Russians have come to these meetings with integrity. I think that they would like to have parity and come to an understanding, because internally, with all their five-year plans and promises for a high standard of living, expending so much productivity on war is no longer tenable. It is a very powerful force.

OZBEKHAN: I believe that the disarmament-and-war problem should be introduced, perhaps not in this paper, but as one when the Conference asks us: "All right; you have developed this beautiful thing, but totally unfeasible, utopian and so forth; how do we get there?" One of the steps is increasing the yield of productivity through disarmament. This is calculable. We can compute how much aid for development and equalization we can give just by cutting out production of armaments.

DE CASTRO: I think that also, as an instrument of operation, we should have in our document something about war and disarmament. I see it as important that scientists—and I believe the majority—have arrived at the idea that we need to persuade Government that the security of the world depends on more equity in terms of development. I have been for four years head of the delegation of my country, Brazil, to the conference on disarmament. My colleague Ambassador Foster, representative of the U. S., once said to me, "The more guns we have, the less security we have. Guns don't solve any problem of security." That is absolutely true.

I would also like to tell you that the Treaty of Moscow that was talked about in terms of atmospheric nuclear explosions was liked by neither the United States nor the Soviet Union. Actually, both were against it and neither wished to sign it. It was proposed by Brazil. I myself proposed this type of treaty. The U. S delegate Foster told me, "We are against it," and the Russians told me, "We agree, but the Americans are against it."

One day, after three years, there was an incidental circumstance in which Mr. Profumo, Minister of Security in the United Kingdom, had so much bad publicity because of his scandal with Miss Keeler; he was then replaced by the man who was to head the Conference on Disarmament. He told me, "The Conservative Party is in a bad position in the British Isles. We must convince the United States to help us. We propose that we improve the situation of Mr. Macmillan, and perhaps we can win the election." It was done. It is not absurd that we utilize a sudden moment; it can arrive tomorrow, or after the Vietnam War and the complication of Cambodia. At this moment, the big powers have cut—2 percent in the United States and 4 percent in the Soviet Union—military expenses because of the pressure of public opinion.

I believe we must not only say how to do it; my view is that this is one of the fundamental things: No one can deny that war is absurd, but one of the most terrible absurdities of our time is that no one dares to make a major war, and yet we are preparing for a war and spending $200 billion a year to prepare for a war that we cannot dare to make.

KING: With regard to the whole aspect of participation, we haven't brought in the level at which decisions have to be made. I think we should recommend initial tactics with regard to the intermediate steps needed to begin to move rather quickly toward a change in national goals.

OZBEKHAN: I feel that this is an exploration of something that has not been anticipated by man.

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Report of Working Group on Economic and Social Policy

1. We are unanimous in our conviction that humanity is at the danger point of its evolution. In a world supposedly rendered impervious to war by atomic weapons, we are nevertheless engaged in wars and live amid events that narrow the spectrum of our options. A number of continuous problem areas have emerged whose symptoms are increasingly obvious to all men. Examples of these are the progressive degradation and poisoning of the environment and the major disparities between the rich and the poor nations, which mean that a large proportion of the world's population has little possibility of decent conditions of life. Furthermore, explosive population increases threaten famine in many parts of the world. Other signs are the sterility and frustration of life, especially urban life; the alienation of an increasing number of individuals who realize they have no say in decisions that greatly affect their lives; increase in crime and delinquency, and a constant devaluation of human personality. These problems seem to accompany affluence and technological development in the advanced countries and are accompanied by a loss of confidence in the effectiveness of our institutions and political parties, and with the failure of religion and its institutions to provide a coherent point of view. They are evident in other forms in the developing countries.

These critical problem areas are global and seem to arise in all industrialized and nonindustrialized societies, whatever the social or economic system. They are, by nature, exceedingly complex and are interactive to the extent that it is increasingly impossible to think in terms of clearly defined problems and clearly defined solutions.

We are convinced that this highly intermeshed cluster of problems cannot be tackled by our present motives, attitudes, approaches, political and organizational processes, and institutions; that mere modification of these will bring only marginal improvements of little or no relevance and that unless a completely new approach is taken quickly, the result can only be disastrous to the human species.

2. We feel that a solution must be sought through a global, systemic, and normative approach, based on new values that take account of the potentialities and rights of the individual and of the species itself. This will require a substantial discontinuity in the current momentum of society and a new approach to education. Change limited to economic or even socioeconomic policy seems to us insufficient for the creation of a new reality.

3. We feel that it is necessary to start, in terms of a perspective of about 20 years, to explore the main desirable characteristics of society and plan now toward the achievement of such a society.

4. The goals of tomorrow cannot be meaningfully visualized in terms of today. By as wide participation as possible, the basis of a new ethic must be established whose values will determine the individual goals and detailed nature of the society to be thus constructed. Such an ethic is essentially the definition of "the good" in light of the new situation and not of present conceptions of their linear extension. Many fundamental questions will have to be asked early; for example, should the world of the future be based on economic growth through industrialization, as now? A necessary prelude to consensus on goals would be the definition and institutionalization of the means

and methods through which a process of continuous convergence attuned to changing situations can be achieved. Thus, in the setting of policies and strategies, maximum flexibility must be ensured to allow change and dynamic adaptation of the policy-setting process itself. Participation of those cultures, nations, and social and professional groups that today have little or no say in the shaping of the future must be made possible. Only by such means can the wealth of creative, original, and innovative capacities that are suppressed or neglected today contribute to widening the range of possible alternatives.

5. An essential step will be to define a new bill of rights and obligations of man in 1990, of which the first article will be the right of each individual in the world to a guaranteed decent share of the world's goods and services, irrespective of his occupation or contribution to society. This must ensure his food and shelter and opportunities for health, education, and cultural development.

6. Achievement of this will be possible only through the formulation of global population policies that take into account the future of the species as a whole, and if the enormous energies and resources now wasted on armaments are liberated and put back into the productive cycle.

7. Achievement of such goals can be only through a radical change in political structures and institutions. A world organization will be essential, necessitating abolition or substantial modification of national sovereignty, required in any case to prevent war and permit disarmament, as well as to facilitate a rational distribution of goods and to generate a world revenue necessary for the creation and maintenance of many services that will be required on a global scale.

8. Such an organization would lead to a rational world pattern of agricultural and industrial production and distribution.

9. The above changes will necessitate new concepts of regionalism. The global approach means much centralized consent, planning, and research; nevertheless, decisions will have to be made at regional and local levels as well, depending on the issues, to encourage the maximum of participation. Although there will be much uniformity of structure and method within a world system, diversity will be a quality requirement, because different cultures represent different methods of coping with the environment, both natural and man-made.

10. The political and institutional changes required to bring about the type of world desired for 1990 can be achieved only by public appreciation of the nature of the present predicament of mankind and of the possible plans to meet it. People of knowledge and vision have a particular responsibility to inform and influence both governments and the public.

11. A number of immediate steps are recommended:

(a) Research should be started immediately to define more clearly and in detail the critical problems facing man, with emphasis on their interactions as well as the interdisciplinary and transnational nature of the problems.

(b) Groups should be set up, at first composed of scientists and other independent individuals and later by governments and transitional entities, to develop policies towards the achievement of 1990 in which (i) new world, national, and regional goals will be formulated and (ii) interacting and integrating strategies of economic, technological, educational, and social policy will be developed.

(c) Government centers should be set up immediately for the assessment of social and cultural as well as economic consequences of alternative technological de-

velopments. There should also be a world center for the development of methodologies for such assessments as well as to ensure dissemination of the national results and to act as a world early warning point on environmental and social threats.

(d) We think that further economic growth in the advanced countries is necessary but should be undertaken not as an end in itself, but as a mechanism to provide the resources for worldwide social development. A new basis of growth measurement is required that includes social and quality elements in addition to economic factors.

12. The foregoing is predicated on an understanding of the fact that today we have at best very primitive methods for infusing our goals with operative meaning and relevance. Hence, we recognize that one of the most urgent tasks that confronts us is the development of methodologies for the setting of goals that are valid and legitimate within the context of a dynamic evolutionary reality. This task is the central responsibility of the emerging social science.

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PART III. WORLD UNIVERSITY PROGRAM

WORLD UNIVERSITY PROGRAM
WORLD ENVIRONMENTAL SCIENCE AND ACTION

Chairmen: Harold Lasswell, Hugo Boyko
Cochairmen: Boris Pregel, John McHale

LASSWELL: We have the pleasure of having Dr. Hugo Boyko with us. All of us are aware of the decisive initiative taken by Dr. Boyko in establishing the World Academy a decade ago. We are equally aware of his concern for the development of a variety of activities through and sponsored by the World Academy. One of the most important of those activities was, of course, the conception of the World University. I trust that our general discussion of the present state of development will allow us to engage in a general discussion of trends, possibilities, and suggestions. Our first step will be to hear from Dr. Boyko himself.

BOYKO: I am grateful and much appreciate Professor Lasswell's kind words. But deep appreciation must go also to all my co-workers. Without them I could have done nothing. It was their enthusiasm that helped us and drove us forward. The time in which we are living helped the development of this idea. Fifty years ago it would have been nonsensical. But now science is the only really transnational discipline. It crosses the political borders that divide mankind and groups, borders that are obsolete and should have been changed.

One of the greatest challenges for our younger generation is to make our planet, in truth, a better place for living. But the younger generation does not yet understand this challenge, which may be the greatest challenge to man since prehistoric times.

Science has now found the means to change many of the obstacles we are confronting. And the young generation will be able to work out the answers, using the results of science, but only if supported by political leaders, educational leaders, spiritual leaders, and so on. Only with close cooperation among the various leaders and young people will we be able to overcome the dangerous factors that are now endangering our environment.

The World University, which we have created and which has now started several units, will, with your help, create a number of commissions, committees, and working groups. In two fields, I have already begun cooperating and coordinating efforts with a number of institutions of higher learning in various countries in the United States, Europe, and Israel, and I hope these efforts will soon spread. The two fields are the fight against water pollution and air pollution and the regulation of deserts. The two are closely connected, although this may not be seen at first. Both may be won by certain recent developments, partly in Israel, partly at the Max Planck Institute, and in other places. This is only one example of what can be done with scientific task forces and commissions if they have support from the leaders in other fields. We will succeed, with certainty, in a relatively short time, perhaps the next 10 to 20 years, and we will make our planet a better place to live in for the whole of mankind. This is my conviction.

LASSWELL: I will sum up briefly the present objectives and experiences of the World University group. As you may be aware, the World University is

in process of formation and has some exploratory activities under way. To summarize:

First of all, a number of institutions have been invited to become centers of the World University. These invitations are issued on the basis of a selective and assisting process that began with Dr. Boyko and that is continuing. What Dr. Boyko and others had in mind was the advantage of developing a truly transnational structure that would be relatively independent of government, of the official structures, even of organized universities and established science, but would be sensitive to the importance of seeking out the most important centers of interdisciplinary activity where there was concern at the same time for the social consequences and the policy implications of knowledge.

Part of the objectives, then, were served by selecting centers that were obviously interdisciplinary in their structures, that were obviously directed by men of enough imagination and vision to guide the emerging potential structure. The choice of centers is dictated by those considerations. It is clear that centers of activity need to be brought into continuing and close association with each other, and a number of suggestions have been made for maintaining continuing work, affiliations, activities among centers. One of the most imaginative ideas allows for the exchange of selected seminar groups—in response to initiatives, questions, problems—originated by a center. Tapes of these discussions would be available for distribution, further development, and comment in the whole process of developing the communicative activities of the several groups.

Many other suggestions of this kind have already been explored, and this represents an example of the kind of structure of communication that has so far been considered. One of our many opportunities here is that of exploring the great range of existing possibilities for developing within the frame a variety of activities that will serve many purposes.

A second major structural feature is the one that figures most prominently in Dr. Boyko's activities: the development of a mechanism of initiative through continuing commissions of the World University and the World Academy. The idea is to develop a series of specialized groups concerned with the clarification of policy objectives and strategy, with the clarification of the technical possibilities of the relevant legal and governmental structures and the ways of mobilizing support for significant policy clarifications and action.

These several commissions, it is believed, can provide, through their liaison activities, continuing contact with other scientific bodies at the national level, at the transnational level, and in official governmental and private agencies. The structure of the commission is a major feature. A number of proposed activities have been partially explored. But one of our objectives is to discover more scientists who are willing to commit themselves to continuing activities of the kind that we have just sketched. It is the mechanism of a continuing commission that we're emphasizing at this moment.

A third potential, which I will refer to in passing, is the importance of developing personnel—personnel that will have the facilities to develop from whatever their base of skill, to develop the role of the integrator, the imaginative interpreter, of the significance of knowledge for policy. One of the objectives for the fellowship programs of such an institution would be to develop, through time, the personnel with the experience and motivation essential to perform this function.

I have referred to three of the mechanisms. I have not referred to the more traditional mechanisms that we take for granted—those for cooperation and intermittent conferences. There have been intermittent conferences set up through the mechanisms of the World Academy, with the cooperation of the developing University.

Only one other point at the moment needs to be underlined before we proceed to general discussion. We are very much concerned that the mechanism of the commission be effectively employed to identify the individuals of every age group who are willing to participate in activities of the kind we have outlined. We are concerned eventually with the development of all types of exploratory institutions and educational and communication activities. It is, however, at this moment relevant only to make reference to these concerns, because, at the moment, many of the activities are in the blueprint stage and will be effected only by the development of the institution as a whole.

Within the last few months, the major thrust has been that of developing the centers in this initial way, particularly the mechanism that will allow the eventual self-selection of men of commitment to knowledge in its relationship to social consequences and policy implications. The World University movement has gained a tempo that I'm sure Dr. Boyko did not envisage many years ago when he began to take his specific initiatives. At the present moment, the environment of institutional development is enriched by a great variety of initiatives taken to accomplish various tasks; the programs for the structure that Dr. Boyko has initiated are intended to adapt the differentiation to the changing environment in such a way that there is effective linkage effective functioning relationships, with the significant initiatives that are emerging.

PREGEL: I think we can go now to certain activities that we have considered and that we may wish to recommend for implementation—if our colleagues here find that a workable idea.

But first, I might say that we have to consider our financial position which has not yet been well established, so that we can finance activities throughout the world, set up centers, and so on. But there are today conditions that demand that the World Academy and the World University embark immediately on certain activities. About three years ago, when we first considered this conference, our idea was not exactly in line with the way it has developed. During the preparatory work, we found out what had to be done and I am gratified that the initiative was taken not to hold a conference specialized on some particular area, but to hold a fully interdisciplinary meeting. Our results may not be decisive. But we all recognize one thing: that such an activity—organizing a conference of this kind—could be done only in the work that was set up by the World Academy and the World University. I hear today a few proposals that this kind of conference, of which this is the first example, should continue, because such meetings may be of great interest and may be the beginning of a new era of conference communication.

We have also an obligation to concern ourselves with the immediate provocative concern of the hour—ecology—and to discuss the question of organizing international, transnational, institutions that would study the subject. Ecology has become immensely popular, and the field itself is polluted. Everybody from students in the third grade to the highest officials in the country is trying to do something with it, some for political reasons, some for other reasons. There is no real guidance, and there is not yet any real international cooperation.

If we can take the lead, it might prove extremely interesting. Because if there is one international, transnational question, it is the problem of ecology. We would have to study, we would have to plan, and we certainly would need all the help we could get. We have all the facilities for this, because the World Academy has lists of fellows everywhere who have so far been dormant and would work hard if we gave them something interesting to do.

We are sure there are many scientists here who are not members of the World Academy who could be, one day. And there are others with whom we will meet in other conferences that we may organize. So we have to consider exactly what we should do now. The development of the World University is a slow-going undertaking. We cannot expect, in one year or two years or even three years, to create something that will be an important part of the globe or something that will have immediate transnational significance.

There are other endeavors that may proceed immediately, however. We could undertake, first of all, preparations for a second conference of this kind, if we can work out a program, if we can consider all the defects of this conference and find a means of organizing the next one in a better way, a more elaborate way, a more efficient way, and also, at the same time, we might try to organize a transnational, international, institute of ecology, and implement many of the suggestions that may emerge from this meeting.

McHALE: I will be brief. Let's get down to practicalities. We should regard this conference, this experience—intensive, sometimes irritating, often abrasive—as simply part of a constant transnational activity in which we are engaged as part of our professional lives. Most of us belong not only to one World University but to a number of world universities. The old idea of the "invisible college" is apparent in this room.

So, the conference itself should be regarded, in a sense, as one of the sessions of the World University. Think of it in that way. You are now part of the continuing process. Most of you will go back to your institutions, and in one way or another those discussions will be forwarded. Many of you will go on to other conferences and will carry from here certain kernels, certain ideas, certain kinds of policy or question formulations that you'll again discuss. In a sense, what we are talking about is something that already exists. What we need, very obviously, is to institutionalize, to invent much more consciously that which we are already doing unconsciously. We have already, I think, principally through science, brought out and developed those kinds of transnational agencies and mechanisms that do in effect transcend national sovereignty. We have suddenly invented the instruments that effectively destroy national boundaries.

We ourselves are engaged at the world level. The idea of a World University, in a sense, is a charge to our responsibility to recognize a process that is already evident in our world. We live in a planetary society. We need planetary institutions, if only for the physical preservation of the biosphere.

World science's prime charge may be, for the next two decades, to determine how may man live and survive physically within that thin film of air, earth, and water that surrounds us and on which all of the organisms of the earth live. The World University, whatever it's formulation, is one of our instruments. We are already in the process. How do we now go forward and formulate more clearly its goals, its objectives, its institutional arrangements?

HEDÉN: On the question of the environment, this proposed group is certainly important and very timely. But, as one considers the establishment of such a group, it is extremely important to consider its input levels.

There is something called the International Conference of Scientific Unions, which is composed of all the 15 or so international unions. ICSU has established something called SCOPE, the Special Committee on Problems of the Environment, which is essentially the creation of the International Union of Nuclear Physics, the International Union of Biological Sciences, and a few others. There is a problem with SCOPE. It commands tremendous expertise, but this expertise is limited to the life sciences and the earth sciences. This structure doesn't include anthropologists, sociologists, and other scientists. This is a function of the structure of ICSU. And I am certain that many within the ICSU structure have discussed this limitation in structure and would welcome contacts with a group that includes anthropologists, psychologists, and others who would come from our particular group. So I would suggest that we try to place emphasis on that level so that those two activities can complement each other.

UNIDENTIFIED DISCUSSANT: The name of the university suggests a certain structure. I see the emerging university, whatever name it might be given, in terms of a newborn organism that is exploring its capacity for doing things; but the old-fashioned, standardized approach to education and disciplined activities must be maintained. It should be conceived as an open system, with all kinds of inputs and outputs and feedbacks, and so on. This university would be able to perform only in terms of its capacity to take the pulse of today's world, and this is the moment where the under-35 must come in—and very, very fast. As Margaret Mead has said, we have never lived in today's world as the young are doing. What I am aiming at is: do you have clearly in mind the very many built-in instruments for change, adaptation, innovation, and change again as the body shapes itself? The under-35 will have to come in as long as the people who are running the university have opened their inner ear to listen. It is an open-ended functional structure that I would like to see visualized.

LASSWELL: Labels like "World University" do have all sorts of negative carryovers and may act as a limiting device on the potential for growth that we anticipate. All of the alternatives for naming, labeling, and so on are certainly open to reconsideration through time; that's precisely one of the major objectives of the process of continuing innovation and change.

MARSCHAK: I wonder to what extent you are aware of the existence of or the feasibility of the U.N.'s attempts to set up an international university and the progress they have made. I am somewhat familiar with this operation, and there's a good chance that the first campus—although not established—will soon be assigned to set up several centers to study global problems. If that does turn out to be the case, what is your feeling about your association with them, and, in general, what is your reaction to that development?

LASSWELL: There are a number of disciplines whose representatives here have been very active in this area. Professor Bergmann, I remember that you were one.

BERGMANN: I have been slightly connected with the work of the group and the difficulties of finding a name for such a group. The registered name of the group is "Universities and the Quest for Peace." The idea was to create a research center someplace in the world where the problem of peace, on an

academic level, could be studied. It turned out that the center would be established in Vienna. The United Nations has given its approval to that, and the Austrian Government has agreed to be the host.

The idea of the center is not to create a new university but to have a place where people from various universities interested in this research could come together to consider specific problems connected with the quest for peace, on an academic level. There would be a staff of young people who would undertake research there for one or two years, but no longer. There would be a constant exchange of people, with nothing that would be constant and institutionalized in the way universities normally are. There was great response to this idea. The congress in Vienna in August, 1969, which was attended by people from many countries, all representatives of various universities, decided to go ahead and establish such a center.

I want to emphasize, and I think it is important in the context of what we are talking about, that it is meant to be a research center on a given and well-defined project. It is not something diffuse. As far as I know, there are about 200 universities throughout the world that have undertaken to participate in this project.

NG: I belong to the generation under 30, and I see the chances of our surviving becoming grimmer. I think the task before us is clear. We must begin to think the unthinkable and do the undoable, or else the unthinkable will happen, and it will not be what we think it will be. We have all just participated in an exercise within this World University. There is, on the other side of the campus, an act of violence that has been committed.

What is the world community doing? This is the World University in action. The World University has been in existence for several decades, I think. But revolution has transformed the entire whole world into a global village. Our task is to determine how we are going to begin to communicate with people with whom we cannot begin to communicate.

What ideas can emerge out of this that will increase the chances of my generation's survival and future generations' survival? If we can begin to direct ourselves to that attack, I think then the World University has some meaning.

Unless we can begin to capture the world and the inspiration of all mankind, whether we call it a World University or something else, we're in serious trouble. Perhaps—and I propose this as one possibility for the World University to consider—one of the tasks would be to help determine what urgently must be done. What are the top priorities that must be accomplished within this decade, and what will our physical and human resources be able to accomplish?

DE CASTRO: For a long time I have admired the efforts and the work that have been done by Professor Boyko and his co-workers on the creation of an international university. But, while I am enthusiastic about the idea, I have doubts about its feasibility. Somebody here said that the United Nations is interested in the idea of an international university. I have with me the resolution adopted by the General Assembly, the 183rd Plenary Meeting, recommending to the Secretary-General that he undertake, in cooperation with UNESCO and other agencies, a study of the feasibility of an international university, including a clear definition of its goals and objectives. The Secretary-General, in the introduction to his annual report, said: "In recent months I have given much thought to the establishment of an international university. The idea occurred to me because my attention was drawn to work being done by individuals to establish an institution of learning with international character."

Later he said that his primary objective for the international university would be to promote international understanding, both at the political and the cultural levels. This, of course, includes everything. The Secretary-General charged Ambassador Lall of India with the job of promoting contacts to consider the feasibility of this project. And the report of Ambassador Lall shows that there are 100 projects for international universities. So I would like to know if this one is to be the 101st? It seems to me that we must not be, after 100 projects, merely one more. We must envisage something different—specifically the promotion of a body that will be capable of forming, of training, the world for the world of tomorrow. If we need to have men able to discriminate among different types of priorities, we have to create something different, something that's not a classical university.

We must fix very clearly which are our goals and objectives, and they are different from those of other universities. If not, we will continue to be one group like many others that try to do something—and something *has* been done—but not exactly all we need. We have reached a desperate moment and must concentrate on realizing all the possibilities for human resources everywhere. I advise that we see exactly, clearly, what kind of institution we would like to create. Without that, I am not too optimistic. There are hundreds of projects run by universities.

I would like to tell you about some other organizations interested in this type of project. For instance, the International Center for Development, over which I have the honor to preside, has conceived a project to create an international university for development—and only for development. And this university is not at all monolithic. We think that we must not duplicate all the wonderful laboratories that now exist all over the world. It would be absurdly expensive to duplicate such equipment in a university that would have to be gigantic to cover all the fields of development.

What is developing today is everything in the biosphere; everything is development. I go further. Development is everything in the cosmos. In this case, a monolithic university would be absurd. Our idea is to federalize a certain number of centers, universities, all over the world, choosing according to their capacity, helping some to improve their material and human resources, and training certain types of scientists or specialists; even in the Third World there are universities that are well equipped now for programs of research, training, teaching. For instance, in Peru there is a wonderful school of agriculture that has been equipped by the Ford Foundation; it is better placed to teach a program of tropical agriculture than anywhere else in the world.

We could have in the Third World, and the capitalist world, and the socialist world, universities that could be incorporated into a world university. But all these specialists, after they finish their specializations in this university, will come to a center that I call the Global Center of Globalization to get the larger view and to apply in a special way their knowledge for real development. We are now of the opinion that we cannot have a single global center, but we need at least three—one in English, another in French, another in Spanish—to start. That is a project we presented four years ago to Dr. Boyko in Geneva. I don't think it is the same thing that has been presented here, because our idea is, as I said, to specialize in programs of development.

To finish, at the University of Paris we are trying to do something different and new. For instance, we constantly have our objectives, our records, our discussion, our teaching, in two fields. One is the field of the Third World, the relationship between the world and the Third World. And the second is the ecological problems of our era—ecology considered not only as the natural ecosystem, but all of the change that is inaugurated by progress in a period of tremendous speedup in development. This is an example of something that has been done and is being done everywhere. And this World Academy could concentrate on and call attention to and help bring scientists together to multiply the efficiency of this study for the real development of man.

BOYKO: May I speak a few words only on this problem? I have spoken with several leading individuals, and they come always to the conclusion that whatever the United Nations will do in the direction of a world university will be under the auspices of certain group interests, and will be subject to the pressure of group interests.

We are not dependent on anything like this. Many programs that the United Nations or any other institution wants to do we could do in a much easier way. These institutions will be complementary—complementary in subject and in principle. If we are speaking about ecology—and I have some experience in this field; I introduced ecology 40 years ago at the University of Vienna and it was found ridiculous: everybody is an ecologist. What do we need an ecologist for?

Ecology is something that only now is assuming importance to large groups of scientists and politicians and so on. At the moment, there are very few real ecologists in the world. It is, of course, not true that everybody is an ecologist. We have a few teachers who could educate more teachers; this group should be utilized as much as possible. The main task will be to educate hundreds of real ecologists who will be able to spread the scientific approach. For this, a certain revolution inside the universities will be necessary. And, in this respect we are in a better situation than the United Nations, for we can complement each other and exchange the different tasks that *we* can do, that *they* can do, and so on. This is my idea with regard to the United Nations. It is not competitive; it is a complementary institution.

MARSCHAK: I have been involved with some of these things and could suggest possible ways of working together. I think the remarks just made are very much to the point and could help us establish a cooperative relationship.

I should explain that I was asked by the American Academy of Arts and Sciences to head a committee on world organizations and educational research. Like many other people since 1919, we came to the world university idea. I had various small meetings, particularly with social scientists, for the purpose of generating memoranda of the types of things necessary for the centers of such a world university—its unique features, an emphasis on global problems, war and peace, problems of the advanced countries, problems of the developing countries, et cetera.

During that investigation, I learned of the existence of the World Academy and was actually on the verge of suggesting a joint meeting. At that time, our committee consisted of several people from Cornell, Rochester, Harvard, and M.I.T., and we had to postpone suggesting the meeting: each of us had problems in our own campuses and we were busy putting out the fires. By the time I got around to it, I discovered the U.N. had passed its resolution and our representative on the U.N. Economic and Social Council contacted me

and I turned over all our memoranda to his study committee, and Ambassador Lall and I had a number of long conversations.

I think it is probably true that achievement of the university will take several years, although plans are moving ahead rapidly. The idea is to set up several campuses. There are hundreds of projects, but it is not intended to have hundreds of campuses. The intention only is to have several campuses distributed around the world. For example, the Japanese Government has offered a building and operational money for the first campus. So, it is moving along. I think the earlier suggestion fits in with this plan. I also agree that there is some danger in the U.N.'s running this world university. I think that if we could unite, we could persuade the U.N. to set it up as an independent organization, so that there would be real autonomy for the various campuses. I think that would be better than having governments breathe down the necks of the people who are running these campuses.

But in addition to that, some of those concerned have been talking about setting up a world federation of international institutes to work together on many problems. If you think of it in terms of a U.N.-sponsored series of centers working on global problems, you can see a real backup by a world federation of international institutes that would be definitely private, not governmental. It would include such things as the East-West Center in Hawaii, the Graduate Center in Geneva, and many others that would enter into it; they would all essentially be nongovernmental and would be affiliated with the main campuses of a U.N.-sponsored university—I use the word "sponsored" because it might otherwise be U.N.-controlled. But even if it were U.N.-controlled, the point is that a world federation of international institutes, many of which now exist, as Professor de Castro just mentioned, would be an excellent example. They could join together on a private basis and provide the backup for the students who would be working at the main centers and could work at these separate centers.

I would like to tell you about a project I have been working on that is connected to this. It is an attempt to set up an international science foundation, which would start with an operating budget of about $5 million a year to give grants to scientists in the developing countries to build up their scientific, technical, and educational infrastructure, to build up their research, to train their own people, to bring their people to applied science and technological projects. This proposal, which I drew up with Roger Revelle, was presented to the Advisory Committee on Science and Technology and Development at the U.N. last year and was approved unanimously by that committee.

In my view, a triple approach is feasible. There are the global centers of the World University; there is the World Federation; and there is something like the International Science Foundation, which could be the activist arm of all these organizations to help scientists and social scientists to carry on the essential work that would further world peace.

MCHALE: What we've heard about is campuses, buildings, foundations, centers. What *we* are talking about is a rather more unique animal. We are talking about the university, if you like. Stay with the name "university," without a campus. We're not talking about buildings. We're not talking about centers as physical facilities. We already live in a world that is electronically linked. I can go to the office upstairs and call Singapore, if I wish. I can call London. We are already linked in this way, invisibly and immaterially.

The emphasis is not on constructing new campuses or erecting vast centers,

vast facilities—no, not at all. The idea is to decentralize the entire operation, to use all manner of existing centers in all sorts of different, cooperative ways. This, I think, is the unique feature we should emphasize initially. We start with individuals demonstrating competence in their own particular fields, and we look therein for those who demonstrate a particular kind of global competence, the capacity now to integrate knowledge for the greatest human welfare.

STUART MUDD: Professor McHale said essentially what I was going to say. We have a great need for coordinated, integrated thinking on the great problems of all mankind. This is so obvious that Harold Taylor has drawn up a book in which he lists a thousand proposals for a world university. This one would not be 1,001, because most of the others have not been developed.

But, as Professor McHale has pointed out, this is not in any sense competitive with all these other efforts. And Dr. Hedén pointed out that we hope we could present an input of a social and philosophic nature into the efforts of ICSU, which is essentially in the natural sciences. We are not in any sense proposing a competitive organization; we are proposing an association of charismatic individuals—with special competence in various fields—who would help to coordinate and integrate human thought on these problems, working with whatever other agencies, resources, and institutions that could profitably be consulted and cooperated with and drawn into a wide-ranging global network of concerned individuals trying to apply their expertise to the solution of mankind's common problems.

CASSIRER: I'm from UNESCO, but I am not speaking on behalf of UNESCO. It had been my intention to speak only about the communications aspect of this, but before that I have to say something about your project. Someone raised the question of originality. It has to have its own very peculiar function, not only in relation to other international projects, but in relation to the concept of the university itself. The word "university" itself implies universal. And therefore what is different from a university in what you contemplate? Is the word "university" the proper word? I'm not sure. What is its specificity?

The second question, which frankly has worried me somewhat at this meeting, is, is it worthwhile? Is it truly worthwhile? Where are the developing countries in this problem? Where are the countries of other parts of the world *here*? What is the *real* scope? From that point of view, with all its imperfections, the United Nations has a much larger scope. So, unless you can match the scope—geographically, ideologically, and politically—that is at the root of anything that can be envisaged within the framework of the United Nations, I do not think there is a real complementary approach. Because one essential element, to take only the developing countries, is the possibility that anyone, whether he sits in Peru or Singapore, in Lagos or in Djakarta, in Moscow or Peking, can be part of an intellectual world. Is this the potential of the World Academy of Art and Science? I don't know, but I am asking.

The third aspect is the question of independence. All of us, at least in UNESCO, are convinced that even if an institution set up by the United Nations were a straight government-dominated institution, it would not be a university. The very idea of a university is its independence. Therefore, where is the connection with independence that would assure this type of independence?

I do not think that any United Nations university would have the right to call itself a university unless it clearly had the financial independence to make it independent of government. To me the originality of such a university would be the confrontation of entirely different points of view—politically different points of view, scientifically different points of view. Unless there is this freedom, I do not see the purpose of it. Otherwise, we might as well work with a few institutions within the same kind of framework. And this is the very test both for the United Nations and for your own initiative.

Finally, one word about communications. It is obvious that any world university today has no meaning in terms of a campus, and I completely support what Professor McHale said. We have the possibility through electronic communication of a linkage that provides an entirely different dimension; we also have the necessity of considering communications as a field of study, as a field of integration. For instance, in ecology, communication is so much at the root of our living together that any university that would neither be based on the use of communication nor consider communication as a field of its own concern would, to my mind, not be living according to conditions of the contemporary world.

PREGEL: I would like to say just as a point of information that we have in the World Academy representatives of 86 nations. However, although the United Nations has many more nations, the people who are there, who will be there, will be chosen by their governments. But the Fellows of our Academy are elected. *We* find the scientists who we think should be members of the Academy—we may sometimes make mistakes—but, in principle, *we* find them, *we* make them Fellows of the Academy. So, from the point of view of the possibility of dissemination of information, of communication, we have 86 countries—perhaps 90 countries. And we can have all nations, if necessary. We can increase the number of Fellows to 500 from the 300 we have now. And the advantage would be clear: These completely independent people, who are free of all coercion, could freely express their opinions.

KLINEBERG: Professor Lasswell, Dr. Hedén, and others made references to the International Council of Scientific Unions, ICSU. I merely want to remind all of us that there are other international councils that should also be involved. In addition to ICSU, for example, there is the International Social Science Council, which includes representatives of the disciplinary associations in all the social sciences, the International Council for Philosophy and Human Sciences, the International Medical Association—and there are others. There are, in a number of disciplinary areas, international associations, many of which—or some of which, certainly—would be interested. As someone who has been with the International Social Science Council since its inception, I think I can assure you of tremendous interest on the part of representatives in the Council of sociology, psychology, economics, anthropology, demography, public opinion research, and even mental health, because the World Federation for Mental Health is also a member. I'm sure they would all be very interested in cooperation.

I also wanted to say that I agree that a university set up by the United Nations would not necessarily be controlled by government. There are many countries in the world where universities are government universities—France, Germany, and many others—and where the universities have a great deal of autonomy and there is no interference with the activities of the university.

It's true that there is general agreement as to what should be taught in the various universities. But there certainly is just as much freedom to say what one thinks about the problems one is dealing with and the teaching

that one undertakes. I'm sure that Dr. de Castro, and myself, and others with experience in French universities would say that it would be unthinkable for anybody to interfere with our choice of specific problems for research or our statements about materials we are teaching. So the fact that a university is governmental does not necessarily mean that there will be control over specifics.

My final point underlines what Dr. Boyko and Dr. McHale and others have said; I don't see this as a phenomenon of competition, that because an international or world university is being set up here, therefore it should not be set up there. If in one case a campus is found or several campuses are found for universities, it does not mean that therefore we could not also work in the manner that the World Academy is working—namely, to use existing institutions to build up this network of communications.

LASSWELL: Thank you very much, Dr. Klineberg. There will be opportunities, obviously, to follow up our lines of discussion and pick up on whatever points seem to be worth pursuing. We thank you very much, Dr. Boyko.



Diners, from left, are Harold Lasswell, Hugo Boyko, Arne Tiselius, Glenn T. Seaborg, Boris Pregel, Mrs. Chester F. Carlson, and Serge A. Korff.

PART IV. CONFERENCE DINNER

DINNER

Boris Pregel, *presiding*

PREGEL: I would like to welcome you to this evening's banquet. We do not have a very long program, but before we introduce the three major speakers, I would like to make a few remarks.

Until the last 30 years, man's whole history has been lived in the shadow of scarcity, of insufficient food, of inadequate shelter. This scarcity has been a measure of the availability of energy. Even the present relative abundance in the United States has not meant sufficient food or adequate shelter for those of our people at the bottom of the socioeconomic ladder. We retain in our vocabulary the phrase "poverty-stricken," and we all understand its connotations.

How many of us have used the phrase "leisure-stricken," or given thought to its implications? Leisure may soon be one of the major problems with which individuals, families, and governments will be faced. The average industrial work week will probably soon be no more than 20 hours. In the not-distant future, it may very well be less. What kind of problems will this create? We can see at once that the problems of leisure will be different for different types of persons in different environments.

In the cities, which are already becoming atavistic anachronisms, our chief concern should perhaps be with those classes of workers who are to be displaced by automation—the production workers with specialized skills and the clerical workers whose jobs will be taken over by machines. In the city of New York alone there are several hundred thousand potential displaced persons. With their jobs gone, deprived of status, their earning power depreciated or lost entirely, these people will be downgraded to the status of unskilled labor, the most dangerous and explosive segment of society. Unless we wish to see violence, crime, and vice increase, we must find ways to forestall these undesirable results.

Retraining these displaced specialists will be imperative. However, the acquisition of new skills and new jobs will not solve all the problems of the leisure-stricken, who will still be faced with the threat of boredom. Our people, particularly the present generation, have not been prepared through education or culture to spend leisure in a socially desirable or dignified manner. We can predict with relative accuracy what use will be made of the goods an economy of abundance will provide for us. We cannot so readily predict the uses to which the new leisure will be put. This will be a problem for all segments of society, individuals, families, and governments. Culture cannot bear the initial burden of preparing us for leisure. Our culture has valued money more than music, industry more than art, food more than leisure, labor more than leisure. This, incidentally, is a good example of the way in which technical developments outrun social progress. It will become a responsibility of government to educate our people to use their free time constructively. The choice is clear, but we must act immediately. It will not be easy to educate large masses of people in one lifetime or one generation, and I fear this is all the time we have. This is a problem that should be faced now, with courage and initiative, lest the tremendous new energies we are about to unleash be turned ignorantly against us. An unpleasant fact remains: that although famine is no threat to the United



The late Chester F. Carlson.

States, it is a continuing and increasing danger in some of the less fortunate nations. The energy supplies available in the world today are sufficient to provide for every inhabitant of the globe the minimum necessities of food, clothing, and shelter. That poverty and famine any longer exist anywhere is the result of defective and obsolete systems of distribution. The turmoil of the emergent nations and the spiritual distress of the West, the anxiety we exhibit, the gloom we feel, can be attributed, I suggest, to our failure to develop in the social field techniques as advanced as those adopted in scientific areas.

Distribution of wealth is essentially a social mechanism. In the last few years we have lived in a world where the distribution of food, clothing, and shelter was governed by a railroad timetable. Today we live in a world of giant supersonic jet airliners. We are unhappy with our performance because we lack the courage to act as if we lived in a jet age. We cling, instead, to the railroad tracks and the slow schedule of the past. We must abandon the past and embrace the future. Technically, we have moved into the 21st century, and we can no longer afford to cling to 19th-century thinking—that of the era of the railroad. This is, of course, a problem for space men, economists, sociologists.

As an engineer, I feel impelled to point out that distribution of essentials is a worldwide problem and requires a worldwide solution. Worldwide availability of energy will make necessary not only worldwide distribution, but a world plan for production. The new world of abundance will be, inescapably, one world.

The scientists who have made this one world possible, who have made it inevitable, have perceived this truth. They are men educated chiefly in schools and universities in which the old concepts of an economy of scarcity and a world divided were accepted as unchanging truths, hallowed by ages. The fact that the scientists could change not only their minds but their hearts leads me to expect and hope that similar changes can be brought about in the thinking of statesmen. I believe mankind will survive, that there will be no nuclear war. The masses of the world fear nuclear destruction. The beneficial aspects of the new discoveries are less apparent to them, especially because many of the applications are so technically complex, and their implications so revolutionary, that it is difficult for the common man to grasp them. Therefore, it becomes the duty of the scientific community, the press, the other communications media, to bring to the masses a fuller understanding of the good life that lies ahead.

This also must be done on a global scale. Along with an understanding of the promise the future holds, the world's peoples must be warned of the trials that are certain to accompany our transition from an economy of scarcity to one of abundance. Some of these troubles will seem, at times, all but unbearable. The day of abundance already has dawned on us, but the situation has not changed in the expected way because a lot of important events took place that the foretellers of the future did not take into consideration. The explosion of the population, the explosion of automation, the explosion of mass production, the explosion of consumption, produced an accelerated deterioration of our ecology, a deterioration that may become irreversible. Cars, trucks, and planes, which appeared on the roads and in the sky in fantastic quantities, polluted the air of our cities. The empty bottles, beer cans, and plastic containers cluttered our landscape, our garbage cans, and our garbage-processing plants. Our chemical factories poisoned and polluted our lakes and rivers. And what is still



Boris Pregel presents Scroll of Honor to Mrs. Chester F. Carlson.

more important, the system of distribution of goods did not really ameliorate, and the poor countries became poorer and the rich countries became richer.

I have to repeat that, because of our scientific knowledge and our technical ability, we are already able to produce whatever would be necessary to keep the whole human race in satisfactory material condition, but we have not moved at all to solve the problems of distribution nor made a real effort to coordinate world production in a meaningful way. It seems that people and governments react only after the catastrophe takes place: nobody is prepared to sacrifice his narrow and parochial interest. It seems that everyone expects a miracle, but there are no miracles in our times, and unless some conditions unexpectedly produce pressure, an unbearable pressure, on the governing bodies of many countries simultaneously, and an authoritative scientific body convinces people of the real dangers they will encounter in a short time, I see a great danger in the future.

This means that efforts have to be continued. Those who are responsible have to continue to do whatever is possible in order to establish a general plan and elaborate all the necessary recommendations and suggestions to prevent the extinction of our species. We hope that this effort will be successful and that our conference will be one of the important steps in the right direction.

* * *

Before introducing our next speaker, I have another important duty, an act of homage to a great man.

This evening we are honored by the presence of the widow of the late Chester F. Carlson, who was one of the most outstanding Fellows of the World Academy of Art and Science. Dr. Carlson, who departed this life so early, was a great engineer and an exceptional inventor. His invention of Xerography reformed completely all existing ideas about copying methods. The Xerox process is the best to serve the needs of science and industry, and without much exaggeration, we can say that since his invention, we live in a "Xerox era."

Dr. Carlson was a great philanthropist and showed a continuous warm interest for everything that could serve to better the human condition. His interests were of a various nature and he was most direct and generous.

We will always remember with great appreciation the important help Dr. Carlson gave to our organization.

Mrs. Carlson, his loyal companion, was a constant inspiration to Dr. Carlson, and we would like now to present Mrs. Carlson with this scroll of appreciation dedicated to her. I will read the inscription:

> With deepest respect and sincere dedication to the memory of our late distinguished Fellow of the World Academy of Art and Science,
>
> CHESTER F. CARLSON
>
> This Scroll of Honor
>
> has been created and transmitted to his wife,
>
> MRS. CHESTER F. CARLSON
>
> In homage to their joint interests and accomplishments for society—expressed both in his individual inventive genius and in their common philanthropic endeavors in furthering of the well-being of their fellow men.

In recognition of the personal qualities of Mrs. Chester F. Carlson, as loyal life companion, sharing the pioneer work of this great man and participating actively in his broad range of interests—and now in continuing the direction and tradition of their joint committment to the larger goals of human welfare.

On behalf of the Fellows of the World Academy of Art and Science.

May 1, 1970

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The next speaker of the evening is Dr. Harold D. Lasswell. Dr. Lasswell is Professor of Law and Social Sciences at Yale University. His position affects the interdisciplinary character of his work, which is demonstrated by the books published in close collaboration with colleagues in several fields, including political science, jurisprudence, psychiatry, and communication.

Professor Lasswell has been active in many countries as a teacher, researcher, and adviser. He is a former President of the American Political Science Association and is now President of the American Society for International Law. Dr. Lasswell is a brilliant scientist and philosopher and a man of universal culture. I have had the privilege of working with him on the development of ideas and at the present conference, and I have been greatly impressed by his sharp, clear thinking, his mastery of expressing exactly the most complicated ideas and decisions.

AN INTERIM REPORT ON THE CONFERENCE

Harold D. Lasswell

Yale University, New Haven, Conn.

This volume, and the conference from which it grew, is a step in the development of the World Academy of Art and Science and the World University, established under its auspices.

Our first aim has been to present a map of the recent and prospective development of knowledge in the physical, biological, and cultural sciences. Hence, the wide variety of papers herein cover the space and earth sciences; biological and medical sciences; physical sciences and engineering; anthropology, sociology, and psychology; economics, political science, and law.

The second and ongoing aim was an examination of social consequences and policy implications of knowledge for the needs of man. And this called for a different kind of procedure than is usual in scientific gatherings and scholarly books. Policy is *value-oriented*. How do we clarify the value goals of man?

Policy is *future-oriented*. How are the value goals likely to be affected by knowledge?

Policy is *action-oriented*. How can general goals be specified in distant, middistant, and immediate objectives?

Policy is *creation-oriented*. How can the creative innovations be found that illuminate goals and paths through the future?

Policy is *contextually oriented*. How can we find procedures that will help us to comprehend the impact of every fragment of knowledge in reference to other fragments within the broad contours of the changing map of knowledge? And how are we to relate knowledge of technical matters to administrative and legal institutions, and with effective support?

Policy is *involvement-oriented*. How can scientists become more effective in the task of making relevant knowledge available in the decision processes of mankind at every level?

The consideration of such questions calls for nontraditional procedures. We made a start at the Conference by dividing into Working Groups responsible for giving policy consideration to a set of important questions. This approach, of course, is reflected in the organization and structure of the present volume.

How does one divide up the big questions? We did it this way: What should be our policy goals and strategies toward "Cultivating Resources"—outer space, atmosphere and surface, oceans?

Or "Population, Health, and Family"—control of population (numbers and quality), environmental control, and public health?

Or "Scientific Knowledge, Education, and Communications"?

Or "Economic and Social Strategies"?

Or "Decision Processes"—conflict resolution and the control of war, the organized planet, human rights, and individual participation?

Each Working Group felt the constraints of time, of new cross-disciplinary colleagues, and of different estimates of the future. The more immediate the objective the more difficult the choice of priorities, the evaluation of cost and benefit, the estimation of the risks.

Obviously, the working papers of the Conference as presented here must be understood as provisional drafts. Plainly, the consensus is that these Working Groups and their like should constitute the nucleus for the continuing commissions of the World University of the World Academy.

This is precisely the principal point of the Conference. Continuing commissions are essential to the work of the University and the Academy, as they are to the general role of science in helping to formulate policies that implement man's needs and values. The commissions are able to count on the active participation of individual scientists in more than 80 countries. They can now see more definitely what must be done at every level of action.

If any lesson has been re-enforced by the experience of the Working Groups, it is the importance of continuity. Why continuity? It is essential if we are to change ourselves into modern men. Continuity is essential even to the revision of our abstract rhetoric of value goals and needs. Our statements are centered on man. Continuing commissions, committees, seminars are places where an *occasional* challenge, at least, can be uttered in the name of *all* life, not simply of human life. How indeed do we conceive of the limits of "man" or even of "life" in a world where the traditional boundaries in the universe of events are fading as the map of knowledge broadens and deepens? We are becoming accustomed to the problem of "human" rights for hypothetical machines. Less esoterically, we need more than an occasional reminder of "Human Rights and Responsibilities" for life and environment.

Continuity is essential if we are to become future-oriented. Continuing commissions and seminars are necessary if we are to be jarred from the isolated consideration of the path of a knowledge fragment to the reception of frequent exposure to the processes of which it is part. This is beneficial to the development of knowledge; it is decisive for the future of man. Unless our value commitments are respecified in the light of future possibilities, they are ambiguous maps for the path of policy. We need to be continually and explicitly reminded that the gap between man's traditional aspirations depends more on constraints within our decision processes than on the expansion of our knowledge.

Small-group continuity is essential to action. Scientists need time to challenge each other concerning objectives—long-range, midrange, immediate; objectives must be clarified in terms of time. For instance we are challenged to think of the implications of a prediction that the rate of scientific knowledge in relatively developed countries is slowing down while the rate in developing countries is going up. Also, consider the implications of the assertion that such "world languages" as English are declining (one percent a year) and that the use of localized languages will grow. Priorities, cost-benefit, and risk estimates change as these action-related assertions are exposed to the discipline of the seminar process.

Commission continuity is imperative for creativity. The occasional prod of a mutual challenge of a supposedly "insolvable' policy problem is a means to immediate or delayed creativity. We are often told that only a few scientists will be deeply committed to the consideration of social consequences and policy implications. Can we think of better means of inducing our scientific and other institutions to change their incentive systems so that more scientists choose new, cross-disciplinary, and "science policy" or "policy science" careers? We cannot afford to depend on the occasional scientist to gravitate into the position of intermediary between scientist and scientist and between scientists and the rest

of society. Continuing commissions can create firsthand understanding of the appropriate intellectual tasks.

Continuity in the commissions and seminars is essential if the contextual orientation is to be kept alive. Unless a scientist is frequently—not rarely—confronted by competent colleagues who raise the question of consequences and implications, he will often happily regress to a private world. Granted that some cannot be and perhaps should not be expected to emerge from that world, the common interest of science and life requires that more be willing to do so. This means that commissions set a model and explore models that permeate the laboratories, observatories, field stations, universities of the globe. Context becomes clearer if we estimate the probable future of some event, including a strategic intervention in the policy process; then we appraise in future meetings the accuracy or inaccuracy of the estimate and consider how our inferences went right or wrong. We may have been too much affected by love or hatred for the New York Times, or CBS, or even the President.

Continuity is important for involvement. Commissions of fellow scientists can help to keep the scientist "honest" when he engages in the rough-and-tumble of public planning, promotion, and negotiation, or in any other decision activity. It is helpful when mixed commissions permeate the boundaries between specialized scientific and public decision-making operations.

We are engaged in an institution-building process. We view the Academy and World University as subject to the criteria appropriate to any institution. Are they likely to contribute distinctively and significantly to the shaping and sharing of the significant values and needs of man?

We are concerned with making a profound change in the strategies of individual and collective ways of thinking and doing. The man of tomorrow must be a contextual thinker. He must be problem-oriented. He must demand of himself that he discipline himself by participating in continuing activities that enable him to achieve his vast potential.

Continuing commissions are one among many lines of Academy or University activities that include centers of research and other devices of a university, dispersed on many campus locations. Having explained why continuing commissions are important and why each is not "just another committee," we propose to explore all the promising procedures now at hand or capable of being invented, in changing the environment of commission members. We deliberately explore the promising "mixes" of discipline, experience in action, age, cultural background, and every other important variable. We intend to encourage many "wild" as well as "tame" means of realizing the information potentials of computer and instant-communication technology. If we experiment with stimulants or depressants other than the conventional ones, it will, of course, be done discreetly.

This Conference was a modest step, in rhythm with all who are willing to face the future with determination and personal discipline. We join with all who accept the burdens and opportunities of our place in the past and future of man.

PREGEL: The next speaker on our program is Prof. Arne Tiselius, one of the most outstanding scientists in the world, a Nobel Laureate and chemist.

After becoming a Doctor of Science in 1930, he was Professor of Biochemistry from 1938 to 1968, Chairman of the Swedish National Science Research Council from 1946 to 1950, President of the International Academy of

Pure and Applied Chemistry from 1951 to 1956, a member of the Science Advisory Council from 1936 to 1968. In 1947 he was named Vice-President of the Nobel Foundation and was its President until 1964. He has been head of the Royal Swedish Academy of Sciences since 1960. He presided at the Symposium in Stockholm in 1969, and the discussions that took place there are continuing now with our conference. A man of great wisdom, a great scientist. I am very happy to give you Prof. Arne Tiselius.

TISELIUS: Last September in Stockholm there was an interdisciplinary Nobel Symposium on a similar theme with the title "The Place of Value in a World of Facts." This round-table conference was in a way a forerunner of the present one, and we had the benefit and the pleasure of seeing among the active participants some of those present here, including some of those who have carried the burden of organizing the present meeting. In my opening remarks in Stockholm I said that what we would try to do there was something rather ambitious, perhaps even overambitious. The same perhaps may be said about the present conference, which is much bigger and also maybe more far-reaching in its aims. We have to remember, however, that the Creator used six days to create the world, and we have been allowed the same number of days here to set it right again.

Nevertheless, after having listened to discussions at this meeting, I am, to a certain extent, an optimist. Above all, I would emphasize that the mere fact that leading representatives of culture in its widest aspects havs been willing to come together here in a very serious effort to review the situation is encouraging in itself—still more so because many such attempts are being made today all over the civilized world and still more are being planned. The press and general public are becoming increasingly aware of the imbalance in our conditions for living and even of the threat against our very existence, and there is a kind of murmur of protest going on that is developing into almost a roar. Even the man in the street feels, sometimes at least, that something must be done.

Let me say that what I miss in all this is a continuity and a coordination. There are too many scattered initiatives, some of them valuable, but too diffuse, and they lead, I am afraid, to very little action. Something must come out of all these discussions—some specific plans or recommendations for immediate action or for action in the very near future. Time is short, and it may even be necessary to put aside, for a while, what may happen in the year 2000. We have to channel all this active interest—all this enthusiastic good will and all relevant facts—to the decision makers, and we have to do it soon. In many cases I believe we have the necessary tools and the weighty arguments. But still it is not easy to get things going. Why?

Man is an irrational creature who reacts only slowly to ever-so-convincing and radical arguments. Is it that we should have to wait until the garbage is literally on our doorsteps? And I am not referring only to the problems of the environment. It is very encouraging that the United Nations has decided to organize a conference on the environment in Stockholm in 1972 on the initiative of the Swedish Government. This, as has been said during the present conference, may act as a magnet to attract the attention of governments and of different organizations and also of the general public to the urgent need for certain measures to be taken and certain agreements to be reached. I hope it will also indicate a way of coordinating much of the valuable work being done, for example, at the present conference and to provide a channel for the realization of at least some of the goals we have tried to set here.

In my opinion, the success of the Stockholm conference will depend largely on such preparative work. Several committees are already in action. A very important task for them is to collect and to review material that has come out of discussions such as we have had this week. This is an additional reason why we appreciate so highly the initiative from our hosts here. This conference is also, from that point of view, very timely indeed.

I said a moment ago that I believe we have the tools for immediate action, at least in certain fields. I cannot help opposing those who like to blame science and technology for many of the evils of the world today. I believe it should be stated most forcefully that even if we admit that such a criticism may sometimes be justified, we are convinced that whatever remedy we look for, whatever tools we hope to use, we will be entirely dependent on continued and intensified research for whatever we try to do. Not only specialized scientific research in its narrow sense, but rather research over the whole field of human endeavor and human existence in the closest collaboration between various disciplines.

It remains to me to express our warmest thanks to the organizers of this conference for giving us an opportunity to take part in a meeting that may become a landmark in our efforts to set the world right. We thank you and we wish you well.

* * *

PREGEL: Before we go further, I would like to say a few words about the help we received during the organization of this conference, and I would like first to thank my friend Serge Korff, who gave us a great deal of help, because, as you know, this conference is sponsored jointly by the American Geographical Society and the American Division of the World Academy of Art and Science.

The people who were in charge of organizing the conference were a very small group. I would like to express my great appreciation in the name of all the people who came to this conference, to John McHale, and I must include Mrs. McHale, because she did a tremendous job and was a great help.

A simple glance at the world surrounding us would convince anyone of the complexities of our life, complexities that are growing with every passing minute. The main problems arise from the speed with which science and technology are moving ahead. Not the structure of our society or the present system of education, nor even our psychology, is prepared for the drastic changes of the last 25 years. The famous dictum, "Gouverner, c'est prévoir"—to govern is to foresee—is certainly not characteristic of our time. The gap widening each day between social advance and the technological process creates a peculiar situation in which governing bodies have difficulties understanding the trends and the problems. They act in many cases—I should say in most cases—with old approaches, which are, of course, inefficient and dangerous.

In the Western world, which should be, in principle, better prepared to meet the situation than any other place in our planet, there are very few men of vision in government. We are still burdened by the legacy of conventional oratory, sometimes demogogic and sometimes just inadequate. Mainly this is because of the composition of parliamentary bodies consisting of professional politicians and lacking in representatives of the scientific and technological world, a tragic mistake in our technological era.

There are some exceptions. We are happy to have in our country, in a most

responsible position as Chairman of the Atomic Energy Commission, Dr. Glenn Seaborg, Nobel Laureate, great scientist, who is more responsible for the largest extension of the table of elements than anyone else in our time. Above all, Dr. Seaborg is a statesman, a man with great vision. He possesses one of the major qualities for a statesman, the ability to appreciate events, present and future, for their importance in our society. In many speeches and reports throughout this country and abroad, Dr. Seaborg brought, in simple and vigorous words, real hopes, based on scientific premises, and kindled the belief in a better future. It seldom happens that one man combines in himself so many virtues, talents, and qualities. I am a witness to the career of Dr. Seaborg. We have known each other, we discovered today, for 30 years.

SEABORG: Thank you very much, Boris Pregel. I notice that in your program I am referred to as the former chancellor of the University of California at Berkeley. I think perhaps you might have made it a little clearer that I left that position voluntarily.

THE POSITIVE POWER OF SCIENCE

To speak to such a distinguished gathering, and one that over the past few days has immersed itself in matters of such importance, is indeed a challenge. This has been a conference with a difficult and most urgent task—that of considering "the environmental and social consequences of science and technology" and, in the light of these considerations, attempting to "formulate policy goals and strategies for the needs of man." Of course, the kind of thinking that has been responsible for initiating this conference and organizing its direction and content has been long overdue. Most of us, I am sure, realize that, whatever has been accomplished during these deliberations and discussions, we cannot be too self-congratulatory. There is a great segment of the public that would tell us we are "too late with too little." And a significant part of that group will go even further and say that we of the scientific community and our work are at the root of much of man's ills today.

Nevertheless, I am not here tonight to add to the despair and guilt of our times. I am not one who happens to believe that we can degrade the environment less by degrading man more. We are not going to save the earth merely by despising ourselves as its inhabitants any more than we are going to build a better society by belittling ourselves as individuals.

I think it is unfortunate—almost calamitous—that in the often sincere effort to establish a better perspective on our past errors and a sense of proportion about our present powers there are many who feel they have to go to the extremes of demeaning man, of denying reason and downgrading science. Tonight I plan to defend all three. I particularly want to speak up in behalf of science and urge that it rise to the crisis that faces it and man. In a sense, it will be the success or failure of science—science epitomizing man's extended perception and power—that may well determine his survival as a species. But it is not science as we have used it in the past that will do the job. It must be science as part of a new human philosophy, as part of a new age of enlightenment that we are entering. And it is both the past shortcomings and successes of science that are moving us into the age. Let me explain.

What we are seeing today in all our social upheavals, in all our alarm and anguish over an environmental feedback and, in general, the apparent piling

of crisis upon crisis to an almost intolerable degree, is not a forecast of doom. It is the birthpangs of a new world. It is the period of struggle in which we are making the physical transition from man to mankind—a mankind that will be an organic as well as a spiritual whole on this earth. I see this transition as a natural evolutionary process, a continuation of the growth and growing complexity of life on this planet. I do not believe that this growth is malignant in nature. It will not destroy itself by devouring its host or poisoning itself in its own waste. Neither will it self-destruct after delivering its message. Rather, it will self-adjust through listening to and responding to that message—one that for all the static surrounding it is coming through quite clear.

I would like to touch on several ideas related to my admittedly broad and optimistic outlook for the future. In each case I hope to bring in the relationship of science and technology to the more general idea. First, let me dwell on the subject of growth. This is something that until recently was a major value but of which we now seem to be developing a deadly fear. Both that growth and today's reactions to it, I believe, are natural and necessary. There seem to be many people today who, with no mean amount of eloquent hindsight, deplore the fact we did not, long before now, predict our population growth and our growing productivity, with its accompanying waste, and somehow forecast our current environmental dilemma. Unfortunately, most great minds of the past foresaw only small segments of the evolving problem. And the values of the past were centered about unlimited growth because this seemed to be to the advantage of the individual and his society. In a world of seemingly endless physical frontiers, where the exploration and exploitation of these frontiers by new human creativity generated and fulfilled new human needs and values, few if any could think in terms of limits, balance and stability.

Many of us who today talk so glibly about our use of the atmosphere and oceans as "sinks" and who have embraced ecology almost as fervently as we have become embarrassed with economics, tend to overlook or forget the facts and feelings of the most recent past. It does little good to make scapegoats of our ancestors or of one or another segment of our society for the crises we face today. Our environmental crisis in particular could not have been theorized or accepted in the abstract before. It was an experiment that had to be lived in conjunction with the other problems of human growth that have evolved and which we must now move on to resolve. I think it was inevitable that man had to grow to this point. He is now entering what must be a period of tremendous maturity. And just as there is written within the genetic code some incipient biological mechanism that stops physical growth at a certain point in life, so I believe there is within our evolving mankind a well-coded message that is now being released. Before I go on to discuss some of what that message means, let me backtrack to discuss the role of science and technology in the growth to which I have referred.

It is obvious that for some people science and technology are among the best scapegoats of the time. They are said to be the cause of most of our ills today. By conquering disease and extending life they have been responsible for an explosion of population. By increasing productivity and raising living standards they have been responsible for depleting resources and polluting nature. By expanding knowledge and emphasizing efficiency, they have been responsible for deflating myths and diminishing man. And by placing enormous power in the hands of man they have brought him to the brink of his own

destruction. The list of accusations is endless, and it is not fashionable today to attempt to answer the charges or put the matter in perspective. It is more fashionable to dwell on man's relationship to the natural world, to lament that he is not more like the animal life from which he descended, and to wish for his return to a simpler, perhaps more primitive, existence.

This approach may be more fashionable, it may even contain a certain amount of wisdom we should heed, but it is not the whole message we should be hearing. The major part of that message, I believe, should tell us not to deny our dependence on nature or, on the other hand, to deny our differences from what we left behind in our evolution. It is this recognition of what we are—with all its potential as well as its shortcomings—and the emphasis on what we must and can become that are important. The fact is that in this transitional period from tribal man to a truly organic mankind, and to a world in which we can live in harmony with each other and in balance with our global environment, we need a new level of excellence in our science and technology and a new degree of integration between them.

There is, no doubt, a great deal of pain and shock involved in this transitional period, for we are breaking one set of long-established natural bonds and forming new ones. The whole process of change produces shock, reaction, and readjustment. There is always a tendency to revert, to flee from the new and challenging, before new understanding and confidence allow us to move ahead. We are living through such times. We are experiencing what Alvin Toffler refers to as "future shock," and it is often difficult to sort out our movement and its direction. For example, take note of the action and reaction of our youth as it resists some change with an antirational thrust—and often a flight from reality—while at the same time demanding realization of a new level of idealism that can only be achieved through change, change employing the highest form of rationality.

A similar dichotomy and flux exist in our confrontation with environmental problems. Many feel the need for simplicity, limits, and balance. Yet we know that what we must do to accomplish the goals we express in these terms entails to some degree the mastery of a greater complexity, new growth, and a dynamic rather than static type of balance. We really do not want to freeze the world as it is now or go back to "the good old days." What we want, if I read correctly the ideals that so many of you—and so many deeply thinking and concerned people around the world—feel today, is a world far different than we have ever known it. Today—at this conference and at similar meetings that are being held and organized—we are struggling, fiercely but fruitfully, I think, to clarify our conception of that world and work toward its realization. We must not weaken or lose heart in this struggle.

What will be the outcome when we begin to succeed? What will the evolution of this new mankind mean? And what will be some of the manifestations that it is taking place and succeeding? Perhaps most important, we will see the elimination of war as an attempt to resolve human differences. It will not be only that war becomes untenable as a form of such resolution. Neither will it be only that through the wisest and fullest application of science and technology we will eliminate most of the physical insecurity and want at the root of war. What may be most significant as both a cause and effect in establishing world peace will be a sublimation of man's territorial instincts, and the aggressiveness that is tied to them, to a new feeling, one of the communality of man in the possession of the entire earth. Men are already in some measure

sharing the earth through international travel, communication, and exchange of resources. As this sharing is enhanced by a parallel releasing of the age-old bond of fear of scarcity and adjustments in the economic system we have built to institutionalize that bond, we will begin to see the true meaning of the brotherhood of man materialize. And as this happens, the tribal loyalty that Arthur Koestler has seen as the root of much of man's conflict will be broken and shift to a new global loyalty—a loyalty of man to all his fellowmen.

Concurrently with this establishment of world peace— and, again, as both a cause and effect of it—will be the closing of the chasms between the peoples of the world. Aurelio Peccei, Barbara Ward, and many others have warned us that we cannot live in a world growing apart in the rate of development of its peoples. What I think we must, and will, see is a new concerted effort to raise the standard of living and productivity of the underdeveloped areas of the world while readjusting the growth of what many feel are becoming "overdeveloped" areas, harming themselves and others by some unwise management of their power and affluence. Anyone fully attuned to the problems of the world today can feel the need for this effort and readjustment. I think it is vitally important that we in scientific and technological fields do everything we can to encourage and work with those social and political forces that recognize this need and are trying to fulfill it. I will have more to say about such cooperative efforts in a moment.

Another manifestation of our evolving mankind will be the reduction, and eventual elimination, of environmental pollution. The organic mankind of which I have spoken could exist but momentarily on this earth if it were to act as a parasite or cancer. It must learn to exist as an integral and contributing part of the earth that up to now has supported it unquestioningly. This can be achieved only by the formulation and application of a whole new scientific outlook and new ecological-technological relationship. This relationship must be based on a nonexploitive, closed-cycle way of life that is difficult to conceive of in terms of the way we live today. We will have to achieve what René Dubos has referred to as a "steady-state world." We will have to think and operate in terms of tremendous efficiencies. We will have to work with natural resources, energy, and the dynamics of the biosphere as a single system, nurturing and replenishing nature as she supports and sustains us. Such a system can be operated at various levels. A steady-state world does not have to be one in which mankind merely subsists and waits for natural evolution to take place. In fact, a steady-state world would be a challenge and stimulus to man's creative evolution—which I believe we should not deny is a natural process and which may be the highest form of natural evolution. Perhaps the organic global mankind that I have portrayed will be the acme of physical evolution on this planet. And I will not try to speculate beyond this point.

I have no doubt that many people envision the concept of such a complex, efficient, and organic mankind as a nightmare—an anthill civilization in which individuals are mere automatons or mindless cells in a emotionless body. I do not agree with such thinking. What I see evolving is quite the opposite of this. It is a world in which the sphere of freedom of action and choice, individual creativity and sensitivity, is enlarged by the growth and application of knowledge and by greater efficiency and organization. These elements buy time and provide freedom. It is ignorance, confusion, and waste that enslave and eventually destroy.

Of course, new values and greater education must accompany the transition to this type of civilization. That is why I believe that the age of enlightenment we must enter must be one that combines scientific understanding with a new humanistic philosophy. We need both now to survive and grow. What will be the role and direction of science in achieving this new age? I believe this conference offers us a good indication of both. But let me briefly sketch what I feel has been the movement of science and where it is going today.

Science, we might say, has become a victim of its own success. Or to put it more precisely, it has become a victim of its own single-minded success. I think this has happened in several ways. First, in going from the broad and general philosophy from which it originated into a growing number of more precise disciplines—each becoming more productive the narrower its focus became—science traded off wisdom for knowledge and, to some extent, knowledge for information. In recent years this process has been reversed, and we are now seeing the growth of interdisciplinary sciences and a striving for a more all-encompassing grasp of the physical world and even broader relationships, such as you have been exploring in this conference. This type of growth is essential if science is to be the guiding force, as it must be, behind our evolving mankind. Science must grow stronger by continuing to nourish and improve its individual disciplines. We need the specific knowledge they offer. At the same time, it must grow wiser through its correlation of knowledge. And it must be able to transmit its wisdom in the most effective way to society.

We have a tremendous task before us in humanizing the focus and feeling of science while at the same time organizing and rationalizing the forces of humanity. In recent years we have not been too successful in either of these directions. That is the reason why we have been faced, and are faced today, with a decline in the prestige of science, an antirational reaction on the part of many of our disillusioned youth, talk of the "eroding integrity of science," and even a feeling of guilt and despair in much of the scientific community. We must move away from all this. We must work toward a unification of the scientific spirit and a restoration of our self-confidence as well as a new degree of respect for science on the part of those who have lost faith and hope in it.

Let me offer some specific proposals as to ways we might accomplish this. I think we should establish more international interdisciplinary conference—such as the outstanding one we have been attending here—and more organizations that integrate our various disciplines, within and outside of the sciences. I believe these conferences and organizations should bring together—for positive, constructive exploration, discussion, and action—participants of varied interests, opinions, and talents: visionaries and realists, environmentalists and technologists, ecologists and economists, theorists and activists. But the purpose of these meetings should not be that of many of the "confrontations" we are witnessing today. We should seek not the degraded power of polarization but the more beneficial strength of unity—that achieved through recognizing and working toward common goals. In this regard I would like to see those scientists who in recent years have done a great service to man by calling attention to his environmental problems now contribute an even greater service by joining their colleagues in a concerted effort to solve those problems.

I think that out of such conferences as we have held here should come concrete programs or ideas that can be acted on, as well as the broader policy-setting type of recommendations. We must give our activists something constructive to act on and encourage the idea that many small positive measures can add up to a significant force. They can develop an important momentum and a spirit that in time can become overwhelming in its total effect.

I think that the information and programs generated at these conferences must be brought to the attention of the public and the world's political leaders more successfully. We have been very unsuccessful in communicating with the public, in bridging the gap between the Two Cultures. Now we must not only communicate, we must involve. We should particularly encourage the participation of youth in scientific and technical activities. Merely to decry their alienation, to speak of their immaturity or their unrealistic, "nonnegotiable" approach to achieving their ideals, is pointless; more than that, it is disastrous. We must at all levels engage them in the realities of life, not in order to blunt their ideals or enthusiasm, but for the purposes of capturing what is good and constructive in them, of harnessing their energy and creativity, of growing with them.

If some sparks must fly between the gap of our generations, let us not use them to ignite conflagrations but rather to fire an engine of human progress. We in the scientific community in particular need our young people working with us, and it is one of the tragedies of our time that so many of them have become cynical about the accomplishments and prospects of science. I believe we can win many of them back, especially by showing them how effective we can be in working toward the solution of our environmental ills. We must prove to them that science and technology are among man's most creative and constructive forces when they are used by creative and constructive men.

Finally, I think that in bringing together the many forces I have referred to tonight, and in emphasizing the importance of their working together, we must establish the leadership and goals to direct and sustain their efforts. Never before has the world had such a desperate need for greatness, for inspiration, for a vision. The cynics today will tell us that any vision we might have now would be a delusion. But I cannot agree. I feel as it says in Proverbs: "Where there is no dream, the people perish." Let us create that dream then and work to achieve it—not only that man shall live, but that mankind shall be born.

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PREGEL: Thank you very much, Dr. Seaborg. And now, I would like to thank you all for coming this evening, and I declare closed this session of the International Joint Conference.

SUMMARY OF THE SENSE OF THE CONFERENCE AND DISCUSSION OF THE WORKING GROUPS, CONCLUSIONS AND RECOMMENDATIONS TO THE CONFERENCE

Boris Pregel, *presiding*

PREGEL: Now that the reports of the Working Groups have all been made, I will ask for comments on these reports as well as on the substance of our discussions over these days.

PLATT: I would like to make a general comment on all the Working Group reports. It seems to me that they are very valuable reports; however, the time scale that is discussed or implied in the reports is not appropriate to the problems. One speaker has suggested that the world is facing its greatest crisis ever, another says that utopianism has now become the sheerest practicality. And we have been given a plan for what must be done by the year 1990. If we survive to the year 1990, it will be because we will have lived through two or three major crises by then. They might come in 1978 or in 1990, and the only way to get through them is to initiate some of the things that have been proposed at this conference before they occur.

In meeting a crisis in 1988, it is not enough to think about it the day before or the day after; it is necessary to have a 10- or 15-year lead time in initiating the bridging operations, the improvements in economic advantage, and so on.

In order to accomplish these initiating steps, we need analysis and research and development, so that we can choose and make pilot studies on the things that must be done. These also take time. If one wishes to meet a crisis of 1988, one must have a world program mounted by 1978. We will have to be doing pilot studies by 1975. We will have to have initiated the research that generates the pilot studies as alternatives; we will have to initiate that research by 1973. In short, the time in which to initiate the needed research and development that is preliminary to these long-term developments is running out.

My estimate is that our time of initiation is in the range of one to three years; it is not 20 years. That means that the possibility of creating successful methods of dealing with the crises of 1978, the possibility that we can get them chosen, mounted, and effective in time—that possibility is dropping by about one percent per week. In about two years, it will be too late to initiate the studies that need to be done in order to mount these world global developments. One percent per week means that it is not appropriate to talk in terms of a Stockholm Conference in 1972, which will then lead to a group of reports like this, referring to a Stockholm or Oslo Conference of 1974, which will, in turn, lead to a group of reports in 1976. The time is the next few weeks or months.

To give an example from the report of the Working Group on Education, world education by satellite: Television is going to be one of the important educational methods. The satellites are going up within about two years, depending on how soon the reactors are ready. If the software is

available—in the form of courses for elementary education, in the form of courses for adult education, for technical training, for integration of biology, for integration of geology, for hundreds of millions of children who have not enough teachers—if the software is available before the satellites go up, the satellites will use the software.

If that software is not available until six months after the satellites go up, the satellites' time will be occupied by old Westerns, commercial interests, and government propaganda. The amount of time available for educational operations will be cut by a factor of five. In short, the level of global education in the year 1980 depends on our mounting software programs immediately in order to have them available by 1971, when the satellite goes up. This is the time scale we must be thinking about, and it seems to me that any talk about time scales of 1972 are much too slow to deal with our crises.

TISELIUS: If I remember correctly, some of the Working Groups have recommended the establishment, within the framework of the World Academy, of a continuing commission to pursue the work or some of the work that has been done here. I would like to suggest that the program for such a commission include a plan to collect information about similar work being done in other parts of the world. It might be, or it should be, that there is a unique opportunity in this Academy, with its worldwide membership of more than 80 countries, to collect this information, find out the kind of organizations that operate in this field, and obtain a rough sketch of their program. I think that will be an extremely valuable service, not only to ourselves but also to any organization that deals with these critical problems.

BOYKO: Because we agree that the element of time is critical, we have already started in a new field with practical steps, with a pilot plan, for desert reclamation, with a coordinating research program on water pollution, as well as work in other fields by Professor Hedén, et cetera. Of course, this is all on much too small a scale up to now and depends for its success on the support of outsiders. That is the main point. I hope this Conference will help to get additional support.

UNIDENTIFIED DISCUSSANT: I wonder if the sense of all this is not to be interpreted as a need for very tough and concrete actions. We have all seen the endless numbers of conferences; all of them no doubt have achieved very important insights, et cetera, in their concern for future developments. But the proposals have to be implemented, and now, with a very tough attitude. Out of this group should emerge a few persons who will approach the situation and will not postpone for a month or a year further discussions or further implementation but will start working next week or the week after that. I would urge the organizers of this conference to see if there is any practical way to implement the suggestions, and I would think in terms not of larger groups but of groups of three or four people, who would go to work at once to provide this tough cutting across bureaucratic nonsense and many other things that produce a kind of scientific entropy that at times has minimized what we would like to see optimized.

PECCEI: We often leave conferences like this one with mixed feelings. On the one hand, we have learned very much. On the other hand, we see that what we have to do is an immense task and very difficult to appraise. I am totally in agreement with Professor Platt: Our timetable to disaster is very short, and we don't know if we will reach that horizon—1990—

or if we will be out of business earlier than that. Professor Platt rightly says we have to start now. If we see what we collectively have suggested for the World Academy to do, it is a wallop of a program. There will be 25 committees and coordination with 200 other institutions. We speak of research, we speak of different lines of action. But what we need in this world, besides going on with research and following different paths, et cetera, is the capacity of synthesis, which is very difficult to find.

If we do not develop the whole picture, of decision centers, which public opinion may evaluate—if we do not do that in a way that can be understood and can be acted on, I think that our timetable will go on. We will continue research, we will have committees, conferences, symposia, discussions, but nothing will be accomplished. How to get that synthesis is a difficult task. If we do not strike at synthesis, we will be lost in an immense implosion of information without going a step forward.

UNIDENTIFIED DISCUSSANT: I am from Sweden, and I would propose three kinds of investigating commissions: The first will make a systematic survey of the failures of similar approaches made so far and will try to pin down the causes of failure. The second is a type that also makes a systematic survey, but of ongoing and past experiences of experimental, academic activities out of traditional contexts, to see what stockpile of experience there already exists so that we do not have to start all over again. There are probably a lot we are not aware of, but we have to have access to this experience, and I don't think we have it. The third should be a number of goal-definition teams in specified areas. They should map out what is going on, traditionally and untraditionally. But what they should attempt is to look on this from a global point of view as an organism, to see what is lacking, what is needed as a complementary action or as a coordinative action.

I think that these three different commissions—and they should be groups of three or four people, so they can work and not just become paper commissions—really ought to be started. I suggest that all those individuals present who feel that they could devote time and energy to this kind of project, register a time assignment for this task with the organizers of this conference, if possible. And another point, which I think is exceedingly important, is the financing of all this. So far as I know, the World Academy has limited funds available, and so, probably, has everyone else active in his respective field. But probably there is some flexibility at different universities and institutions; if the necessary functions could work within the framework of the university or institution, but be coordinated through an organization or a structure like the World Academy, perhaps enough funds would be available to really get something going.

BORGSTROM: I would strongly underline what Dr. Platt has said, but I will put it in a little stronger terms: It is about 50 years overdue, because a large portion of the world is already suffering from the consequences of our negligence in coordinating the essential areas we are talking about here. Against this background, I wonder why we should not attempt to gain time by trying to figure out what are the really important bottlenecks and the most crucial issues that we have to attack immediately.

I submit three suggestions. One is that there is a complete lack of analysis or effort to cope with the "organization issue" as it now faces mankind both in our part of the world and, still more, in other parts of the world. The poor world will add almost 350 million people in the cities in the next 10 years. Looking at my own area, of water and food and other research, I think we have not considered how we are going to cope with the enormous economic problems, for example, with regard to employment.

The second big area is that we have not analyzed our own civilizations in the depth we are capable of, and this, I think is true of all the reports from the Working Groups, which seem to range all over the field. We have to concentrate on the crucial and essential points, and I would say we should be able to, within a three-month period, establish some kind of balance account.

The third point that I think is quite obvious through all the reports is that we have very vague ideas about how people really are living in this other world. The old formulation, the ethnocentricity, are obvious in almost every third sentence; would it not be possible for the World Academy to locate some prominent individuals in different areas—and I would divide the world into about ten areas—where we could get a group of people working together with the Academy in formulating more realistic programs?

Would it not be possible to formulate "development schools," actually for development, concentrating on these bottlenecks and crucial points, not going over the old fields, but trying within a five-year period to really get trained in cooperation with the concerned countries? I put it in terms of some 250,000 to 300,000 of what I would call extension agents. Think of a village in India or in Africa; I see it constantly in my studies of these problems—we cannot go on *our* way, training medical people, home economists, and food scientists. We must train people with general knowledge and understanding. It would be possible to have people who are acquainted with the most common diseases in an area, who know something about storage of food, which is a major neglected area, who know how to cope with water and sanitation problems. It is not a question of new knowledge. We have the knowledge. It is a question of applying it and coordinating it.

This brings me to my last point. Wouldn't it be possible to create a group of highly ranked academicians who seriously had an eye-to-eye talk with the major universities in the Western world, to get away from this extreme specialization, which I once again stress. I think it is essential.

STUART MUDD: I think we are witnessing the undertaking of a task of staggering proportions—the examination of the total condition of man and what we should do about it. The time schedule, as emphasized by Dr. Platt and others, needs a great deal of emphasis; action *is* crucial. I would like to note one very practical issue: to do anything about the questions that have been taken up requires money and time. It requires attention, and the World Academy and its representatives, as organized in the last ten years, do not have the full time or personnel to undertake these jobs.

We can guide a great deal. We can examine the total condition of man. But when it comes to doing all the things that are specified, there is nobody to my knowledge in the whole body who is not doing what he is doing for the Academy, taking part of his time from his own professional obligations, and I submit this is a challenge to those organizations and sources of funding that are concerned with the total condition of mankind. If the recommendations that have been made could be brought into operation in the time scale Dr. Platt talks about, somebody has to provide the funds and the means to get at least a nucleus of people who are going to have the

time to devote their full attention to implementing the ideas that have been laid before us.

MEAD: A figure was invented by a colleague of mine, and I think it is appropriate. What we need now is a *macroscope*, a device for simplifying the whole, so that we can think about it. Heinz von Foerster assured our Group that we do not yet have the technology to simplify in this manner by means of computer, even if we used all the computers in the world. The only macroscope we can possibly have is human leaders, small groups working together, willing to take the total responsibility for the total situation. I suggest that we emphasize the creation of small groups—small enough to work very rapidly and very hard—using the capacity and knowledge we now have. We do not have time to get all the knowledge before we start putting it together.

Finally, although it runs through the Working Groups' reports, it is not clear enough that we are not talking about man *versus* environment, or man *and* his environment. We are talking about man as *part* of environment, and we are dealing with the whole of nature, with man as part of it, not against it, or thinking about it, or dreaming of it. Unless we keep that holistic position together, we begin again dealing with little pieces of the environment while we live in the middle of it.

CASSIRER: We are all keen on action now. I think there is some misunderstanding between what it means to look at the future and what it means to act now. We cannot have action now unless we look at the future, and this is the way I understand the recommendations. It is not enough to *think* about 1990, because we are not going to *do* anything; we cannot *do* anything today until we think about 1990. The only way to develop a global approach is to try and focus on all facets together; the macroscope comes together, focuses, when we look at the future. We referred to the satellites and educational use and said that we need software. This is only a partial approach. We have broadcasting facilities all over the world, including this country, that are not being used properly. Why are they not being used properly? Because the structures are not there, because the financing and political issues are not there.

The primary issue is that the satellites are being built into a world society for public service, and whether you have software or not is not the only issue; there are more fundamental issues. We have the human resources in the developing countries, we have the technological resources that are not being used. One can go to many of these countries and see many skilled people who are unemployed because, for political or economic reasons, they are not being educated.

PLATT: That means we need teams to think about these problems now.

CASSIRER: Absolutely, but you must not think about certain partial things.

WOLF: I am with the ILO. I think we should adopt a proper, balanced attitude between excessive skepticism and excessive idealism. In other words, we should be realistic. One of the sicknesses of humanity is to be late. After all, we were late in the 19th century because we did not realize all the consequences of the industrial revolution, one of which was one of the major causes of war. We will also be late at preserving—what we must try to do is to be as little late as possible, and without being too idealistic, look at what we can do. Reference was made to employment procedures throughout the world. Well, ILO launched last year a World Employment Program. This is just one example of what can be done. I also think that what is being done at this Conference is of tremendous value. I am very sensitive to the great sense of solidarity that exists here between people of the greatest variety of skills and disciplines, and I am sure that whatever further efforts are being made—and they must be made in this spirit of solidarity, and with all our energies—will contribute to world development.

KOGBETLIANTZ: I think we must be frank. Looking at the world as it is, we must be conscious of the utmost failure of our generation. If, at my old age, I cannot respect our society, I understand why our young men cannot respect it. Our task is enormous, our time is short. What we must do, we have begun here. We can give direction. But what we need is energy for action, and we have a great reservoir of energy in our young people. I think well of this conference: We did a great deal, but I did not see many young people here, people under 25; there were none.

If we want to accomplish something, we should not neglect this reservoir of energy, and I hope, at the next conference, we will see our bright young people, because only they can accomplish anything. I will be frank: I do not feel myself, at my age, able to transform the world in which I live, and by which I was formed. But the enormous reservoir of psychologic energy in the young people can effect these transformations. For the last three years I have lived in Paris. In 1968, I was disturbed, as everyone was, by the so-called student revolt. Look at the results. In two years, France has been rejuvenated. Many commissions of young students are working for law and on education. Fortunately, the Minister of Education has used this enthusiasm and desire for change, and it works wonderfully well. Now we have rejuvenation in all directions in France, and she is moving toward a new society. Why was this possible? Because of the action of young people. My proposal is to try to have, in the next conferences, as many young, bright people as we can find. We should not be disturbed by the existence of the insignificant fraction of those who are extremists; they are nothing.

KLINEBERG: It is always exceedingly difficult to estimate in advance the practical implications of a meeting of this kind. But I think we should not forget that among the people here are many who have the ear of organizations that are exceedingly important for the implementation of our program. There are people here, for example, from ILO, from UNESCO, from the United Nations; there are people here who can speak directly to their governments, who have even been asked by their governments in some cases for advice about what should be done. These are things that will not have to wait forever before they get into the public stream, so to speak, and I think we should take a little comfort from that fact. Though we are all impatient to have something done soon, we should not forget that it will be done through the direct communication of our participants with international organizations responsible for work in this area; with governments that, in many cases, are looking for the right things to do in this area. We do have a chance to have a greater impact than the pessimists might think.

GLASER: I agree that there is an immense reservoir of talent and that we have been waiting for it to be employed by the universities. I see a fundamental dichotomy; on the one hand, we speak of parts of the world faced with increased leisure and abundance and comfort and perhaps with loss of meaning and breakdown of traditional values; and, on the other hand,

we see an increasing part of the world faced with poverty and overpopulation and famine. There has to be some sort of transfer between these two worlds so that meaning can be ascribed to both, so that there will perhaps be a future for man. The obvious means of doing this, is, of course, technology; that is the essence of any civilization. This is the way to transfer resources from one area to another.

I propose that each individual in this room go back to his or her university or institution and try to get that university to immediately set up a program for transporting—physically—scholars and students to underdeveloped nations in the world, to transfer their know-how. I think this will be mutually beneficial. For one thing, the cultural interchange will be of such a dynamic nature; the technological interchange will be at the most decisive political and social institutions. This will give a revitalization of relevancy to their curricula that everyone has been asking for.

NG: I am fearful about the outcome of this Conference. We have been too successful in communicating with people we can't begin to communicate with. Our task now is to begin to communicate with individuals whom we do not even begin to know how to communicate with. In a sense, the head has outstripped the body. One views the whole organism as having been decapitated. The ultimate aim is to benefit all mankind, and the question then is, "What mechanism can we devise that could expand the human consciousness in its largest sense?"

I propose some consideration at this point—that if our ultimate aim is really to try to create a mechanism that would facilitate the expansion of human consciousness, perhaps we should then begin to think of devising certain mechanisms that can provide continuing dialogue through sustained action involving as much of humanity as possible. By this I mean people in the street who could not care less about what is going on in this Conference but who, at the same time, will be intimately concerned in changing our destiny as we will have a feedback to them. This boils down to a consideration of how we begin to create a new methodology for problem solving.

I would like to propose certain ideas for consideration. They are not necessarily my own ideas, but I want to share them with you if what we are interested in is creating something that can remain as part of the community of man. The ultimate aim is to be able to affect decision making, with a participatory mechanism that would stir and engage people deeply. Perhaps, if we were really interested in the survival of man, we could try to mobilize the will of all mankind for the dedication of a day, once a year, for humanity. This would be a recurring event, not a one-day thing. Participation could then be sought at every level. The grass-roots level could do their thing, which would be contextually meaningful.

Thus, perhaps, we could have a declaration of humanity incorporating all the various ideas discussed at this Conference. Let us have a worldwide poll to nominate men who are felt to have contributed most significantly. Let these individuals lead a global dialogue on this day in a search for mankind's priorities, to set up agendas of urgency that have been proposed by various quarters. At the same time I would like to urge authors, writers, and artists to dedicate a book, to dedicate a painting, to mankind. Communication satellites could broadcast this as a world pageant, with the rest of the events captured on film: it would be released only a month, and humanity could

then have feedback. We are too competitive and too overexclusive, and I think it is about time we see where the pieces fall.

PREGEL: I think that we have not had enough discussion on the five Working Groups' reports but I would like to answer a question that somebody asked: "Why are there no young people under 25 at this Conference?" For a very special reason: this Conference was a teach-in for people over 35, the people of our generation who are specialists in a wide variety of fields; they have to learn from the other specialists what it is all about. It is not a general, open meeting: we know all the questions of youth; we know that the future is not for us, that it is for youth; but before we go to the future we have to find out what we can tell the youth, and not merely say "participate." With my greatest respect for youth, it lacks one thing, and that is experience. Even if what we did was wrong, at least we now know our mistakes.

I now propose to end the discussion. The wealth of information, the number of recommendations that we received during the Conference, are very important. But, of course, we cannot form all the committees here for all the work we would like to have done. We would like to have suggestions, and we are open to everything you suggest. We would be very glad if the suggestions were accompanied by some fat checks, because we have to put the suggestions to work. To work on the problems reported today I calculated a moment ago, we would need, for the first year, $50 million.

This is not an end of a conference, it is one of the meetings of the future. We will continue, the committees will be established, we will discuss what kinds of committees, we will try to call on people who we know will help, and if others we do not know will appear and tell us that they want to participate, we will call on them. I think we have to work with all existing organizations for implementation. I am not so sure we must work only with the existing international and national organizations, because up to now such attempts have failed; maybe we ourselves will acquire some experience in what we should propose and ask them to do.

This does not mean that I want the World Academy to duplicate any other forthcoming conferences, but I think if we want to do something ourselves, and not just wish it to happen, that we should, first of all, organize ourselves and see what we can offer.

I thank you for being here with us to work so hard: This is the first time I have been to a conference at which participants actually worked hard and actually produced excellent results. This Conference on Environment and Society in Transition is now closed.

IN CONCLUSION: IMPLEMENTING CONFERENCE OBJECTIVES

Boris Pregel, Harold Lasswell, John McHale

A recurring theme of the Working Groups and the plenary discussions of the Conference was the importance for science and society of continuing activities that link scientific knowledge with public policy. The contributions of the scientific community must be a regular feature of life if the social consequences and policy implications of knowledge are to be kept visible, and if the involvement of scientists and of science with society is to be widely understood.

The theme of continuity implies much more than that public policy should take scientific knowledge into account or that qualified persons and professional associations should give occasional attention to public issues. Analysts of the decision process of both governmental and private organizations are aware of the fact that, sooner or later, the makers and executors of policy are unescapably affected by some of the findings of scientific investigation.

The critical words in the previous sentence are "sooner or later" and "some of the findings of scientific investigation." In our interdependent world we can no longer afford the time gaps that have customarily separated the development of new knowledge in many fields from the effective awareness of social consequences and policy implications. Whatever aspect of society and environment was under consideration at the Conference, it became painfully evident that no adequate connection had as yet been made between many scientific findings and public action.

If gaps are to be closed, our established ways of doing things must be drastically renovated and improved. It is necessary to move from episodic and piecemeal methods to continuing and inclusive connections between knowledge and policy. The distinctive institutions of the scientific community need to be better adapted to the task of motivating scientists to participate in decision processes of the larger community. The specialized governmental and political institutions of society need to be more cognizant of the knowledge pertinent to the realization of human values. The institutions of education and public information require drastic revision if civic and public order are to become more adequate to the urgencies of the time.

Members of the Conference who examined the decision process at the national, transnational, and subnational levels called attention to two decision functions where scientists and scientific knowledge can have optimum impact. These functions are referred to as the "intelligence" or "planning" and the "appraisal" or "reviewing" phases of the total process of policy formation and execution. By the intelligence function is meant the gathering, processing, and dissemination of the information required for enlightened action by participating individuals and agencies in the policy process. It is unnecessary to labor the point that physical, biological, and cultural scientists have indispensable contributions to make to the mobilization of knowledge pertinent to the clarification of the goals and the options open to the body politic. The function of appraisal is closely connected with intelligence or planning. It is concerned, however, with past policy, seeking to provide an answer to the question whether, and to what degree, public policies have succeeded or failed. It is

inconceivable that a realistic judgment of such matters can be made without mobilizing scientific knowledge of the options that were available to decision makers.

Throughout the discussion of "society and environment in transition" members of the Conference continually stressed the critical importance of time. An ever-present dimension of the ecological system of which man is part is the temporal interdependency of its component elements. No one doubted that failures of mobilization *in time* were at the root of the degree to which the safety, health, and positive well-being of man are imperiled by polluted air, toxic food, radioactive waste, and demoralizing noise. Commentators agreed that the Conference would be worthwhile in the degree that it was an act in a series of acts designed to increase present awareness of the achievements and limitations of past policy, and the options available for future action.

In view of the opinions formulated at the Conference, the American Division of the World Academy of Art and Science and the American Geographical Society have decided to give high priority to the task of instituting a *continuing review of public policy toward environment*. Such a Review is intended to provide a means by which the scientific resources of society are mobilized for the benefit of official and unofficial participants in the policy process at every level of jurisdiction. It will continually remind the scientific community of their obligations as citizens of the larger community with whom their future is intermingled. The Review will demonstrate to the general public that scientists are actively concerned with the survival of man and with the quality of life. By strengthening the effectiveness of the *civic* order the Review will contribute to the effectiveness of the *public* order as an instrument of goals at once rational and realistic.

The Review of public policy toward environment may serve as a prototype of the way in which our institutions can be overhauled or redesigned to meet the needs of man. It is to be hoped that the reviewing procedure will be systematically extended to every sector of public policy at the national, transnational, and subnational level. Besides the appraisal function, the intelligence or planning function is particularly adapted for the distinctive skill and outlook of scientists and scientific societies.

We assume that individual scientists will find themselves motivated to go beyond occasional participation in appraisal and intelligence functions and devote themselves in varying degree to *promotional* activities intended to mobilize support for action through party and pressure group channels. No doubt some professional men will engage in legislative and other *prescribing* activities. Presumably many members of the scientific community will continue to serve as officials charged with full responsibility for administrative operations (the provisional *invocation* of prescriptions in concrete situations; the final *application* of prescriptions; the *termination* of obsolescent prescriptions).

The scope of the appraising function can be made explicit by considering the contemplated Review of public policy toward environment. The Review is a product of committees that focus on the various policy-environmental sectors. Each assessment will necessarily include (1) *a statement of assumptions about the goals of public policy* toward environment. The reviewers take responsibility for the formulation of goals that it utilizes. No doubt each committee will clarify and lend weight to its statements by relating them to pertinent authoritative pronouncements (such as the language of treaties,

statutes, ordinances, statements by public figures). It is also necessary for each committee of reviewers to specify (2) *The criteria of performance* to be employed in the interpretation of the goals. To some extent it will be possible to select various "indicators" to add definiteness to the criteria mentioned. Reviewers (3) *characterize the performance* of public authorities in terms of the goals and criteria pertinent to each sector of the environment. Each reviewing group is expected to (4) *select the time period* that it covers. In some instances public policy has been concerned with a particular set of environmental problems for many years. Elsewhere a problem has suddenly become visible. In any event, the task is to provide a perspective in which the present and future can be best understood.

Perhaps it should be made fully explicit that reviewers are as much concerned with the "utilization" of resources as with "pollution" and other adverse effects of policy. In broader theoretical perspective the reviewers are responsible for considering any specific issue in terms of the policy requirements designed to maintain a satisfactory ecological system.

A useful review of public policy must, of course, go beyond the evaluation of the *technologies* chosen by the agencies of public policy. It is essential to characterize the *organizational* structures that are implicated in formulating and executing public policy. In some instances agencies have been drastically overloaded with formal authority without having received appropriations and other assets needed if their missions are to be accomplished. Sometimes an organization is poorly adapted to innovate and adapt the operations essential to environmental programs.

Intimately connected with organization structure, though separable from it for analytic and administrative purposes, are *the legal dimensions* of public policy. It may be that the location of authority is unclear, so that constitutional issues arise. Perhaps legal doctrine is confused, so that the decisions made by regulatory and judicial bodies are contradictory. In any case, the task is to characterize the degree to which an adequate "environmental law" is taking shape.

It is often found that the inadequate performance of a function can be ascribed to its failure to *organize public support* by the release of comprehensive and vivid information. A reviewing process must take into account the strategies that have been employed or overlooked for the mobilization of public opinion and group support.

The foregoing summary of the reviewing function shows clearly why such an operation requires interdisciplinary cooperation. Physical and biological scientists must be supplemented by lawyers, economists, political scientists, and other knowledgeable professions. The American Division of the World Academy and the American Geographical Society have invited other scientific and professional associations to cooperate in initiating the first Review of public policy toward environment. The New York Academy of Sciences has already agreed to cooperate and to make its facilities available to the operation.

On reflection it is evident that an appraisal can be planned and carried out at several levels of complexity. The first level, and the one immediately feasible, is essentially a report based on *expert judgment and experience*. The members of reviewing committees or panels are selected from among scientists who are acquainted in varying degree with the activities of public authorities. To some extent they can be expected to supplement what they

know by arranging for interviews with officials, and by the study of pertinent documents.

As the function of appraisal is better understood and more widely accepted, it can be expected to become more complex. The reviewing committees and panels will probably receive funds with which to conduct intensive investigations designed to supplement and to increase the depth and detail of a policy review.

There need be no apprehension that a Review presented by private scientific associations will be ignored by Government officials, party leaders, interest group organizations, public media of communication, or the educational system. The scientists who are most appropriately involved in such an enterprise include many figures who are well known in official and unofficial circles. Their word carries weight; and if they get together in the preparation of reviews, the impact will be intensified. Officials and private opinion leaders will recognize that the modern-minded scientist is sufficiently responsive to his civic obligations to spend the time required to perform a distinctive public service. Such an activity can be expected to build a durable basis of public understanding of the complex contributions made by men of knowledge to the formation and execution of public policy.

Although the *Review of Public Policy toward Environment* is the most immediate contribution of the Conference to the building of institutional bridges between knowledge and action, it by no means exhausts the list. The American Division of the World Academy, for example, is utilizing the channels provided by the World Academy to stimulate Academy Fellows to engage in appraisal and planning activities in their countries or regions parallel to the initiative taken in the U.S.A. Similarly, steps will be taken to cooperate with those who are determined to girdle the globe with a network of truly world universities.

Looking back at the New York Conference, one cannot fail to be impressed once more by the willingness of eminent men and women from many nations and disciplinary backgrounds to take time out from their personal commitments to engage in a common quest for deeper understanding. If we succeed in navigating the "transitions" of today and tomorrow, it will be in no small measure the result of the vision and energy of those who are committed to the permeation of public policy with the relevant knowledge. The goals of man, though remarkably different in detail, are remarkably similar in commitment to the search for a relationship of man to man and to nature that goes beyond simple survival to the release of creativity that continually redefines and improves the quality of life.

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