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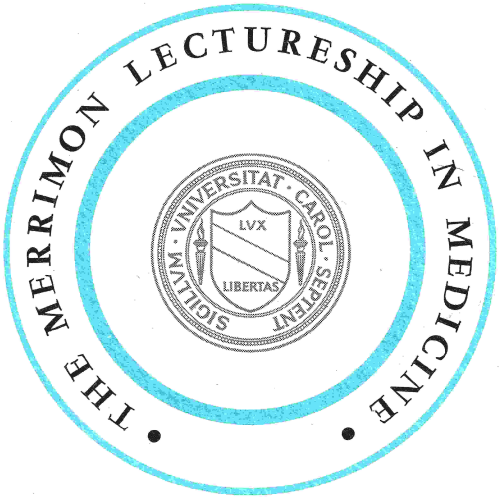
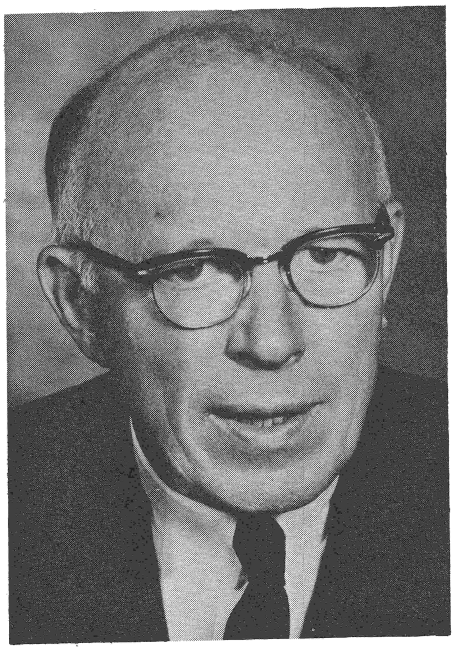


THE MERRIMON LECTURE

by

Dr. René Jules Dubos

DECEMBER FOURTH, NINETEEN HUNDRED AND SIXTY-EIGHT



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THE MERRIMON LECTURE

Scientific Civilization and The Man of Flesh and Bone

by

DR. RENÉ JULES DUBOS

THE MERRIMON LECTURESHIP IN MEDICINE

This Lectureship was established by the late Dr. Louise Merrimon Perry "in respect and honour of the Great Traditions of the Science and Practice of Medicine". It was inaugurated in 1966. Dr. Perry had proposed that the lectures be given to medical students and all others interested, and that they be concerned with "the Origins, Traditions and History of the Medical Profession and of that Ethical Philosophy which must dominate this Field of Human Endeavour". It was her intent and is our purpose that the Merrimon Lectures be given by men and women distinguished not alone for scientific or clinical skills, but also for their notably humane attitude toward Medicine.

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Civilized life can be traced far back in time, but the word "civilization" is of recent origin. It seems to have appeared in print for the first time in 1757 when the Marquis de Mirabeau used it in his essay "L'Amy des Hommes ou Traite de la Population." Mirabeau entitled another essay that remained unpublished "L'Amy des Femmes ou Traite de la civilisation." As the title of this essay suggests, Mirabeau believed that the development of civilized life was chiefly due to the influence of women.

Throughout the 18th century, the word "civilization" had a meaning far more restricted than the one we give it now. It referred to gentle ways of life, humane laws, limitations on war, a high level of purpose and conduct, in brief all the qualities considered the highest expressions of mankind. Nevertheless, Samuel Johnson refused, as late as 1772, to enter the word in his dictionary because he felt that it did not convey any concept that was not covered just as well by the older and better-defined word "civility."

Samuel Johnson may have been correct in rejecting the word "civilization" if one judges from the fact that it is now used to denote several types of human endeavor that are very different and indeed unrelated. For example, the classical civilizations of rational Greece or of artistic Florence had little in common with the industrial civilizations of the satanic mills or of automated life.

Scientific civilization involves much more than the various technologies used to manipulate the physical world, because the use of things is conditioned by the cultural traditions and social practices that shape man's mentality and govern his behavior. Civilization is scientific to the extent that it is based on knowledge not only of things but also of man's nature. In our own times, however, science is shaping civilization much less by its effect on man himself, than by the power it gives him to create the environment in which he develops.

A true scientific civilization should concern itself, not only with man in the abstract, as studied through the limited approaches of

Cartesian science, but even more with the man of flesh and bone. Human life cannot be understood by analyzing the ultimate components and reactions of tissues. Its quality is determined by the responses of the man of flesh and bone to surroundings and events. Some of the worst aspects of modern life have their origin in the fact that technological civilization has evolved without guidance from a knowledge of real human needs.

The importance of this topic was poignantly expressed by Ambassador Adlai E. Stevenson in his last speech before the United Nations Economic and Social Council at Geneva. He concluded with these words: "We travel together, passengers on a little spaceship, dependent on its vulnerable supplies of air and soil; all committed for our safety to its security and peace, preserved from annihilation only by the care, the work, and I will say, the love we give our fragile craft."

At the turn of the 17th century, John Donne realized that no man is an island, and that the bell tolls for us all. Picturesque as John Donne's images are, they were too parochial for so contemporary a man as Stevenson. He changed the parable to spaceship because he realized that we are all dependent, not only on our neighbors, but also on all other men and on the conditions prevailing over the whole earth.

Man on the Spaceship Earth

The expression "Spaceship Earth" is no mere catch phrase. Now that all habitable parts of the globe are occupied, the careful husbandry of its resources is a *sine qua non* of survival for the human species, more important than economic growth or political power. We are indeed like travellers bound to the earth's crust, drawing breath from its shallow envelope of air, using and reusing its limited supply of water. Yet, we collectively behave as if we were not aware of the problems inherent in the limitations of the Spaceship Earth.

It would be easy, far too easy, to conclude from the present trend of events that mankind is on a course of self-destruction. I shall not discuss this real possibility but shall instead focus my remarks on the *certainty* that the biological and social values identified with humaneness are rapidly deteriorating.

Some of the supplies on which man depends are rapidly being depleted; even water will soon become scarce, not only in arid countries but also in the temperate zone. Most environments are being so grossly polluted that they may not long remain suitable for human existence. Smogs of various composition produced in urban and industrial areas are now hovering over the countryside and are beginning to spread over ocean masses. Sewage and chemical effluents

are spoiling rivers, lakes, and coast lines; slowly but surely chemical contamination is reaching even the most carefully protected urban water supplies. Tin cans, plastic containers, discarded machines of all sorts, oil and other forms of indegradable garbage, are accumulating all over the landscape, and in many cases ruining the land. Excessive sensory stimuli, and especially the mind-bewildering noise so ubiquitous as to be unavoidable, threaten to destroy the human quality of urban agglomerations.

The ancient words soil, air, water, freedom are loaded with emotional content because they are associated with biological and mental needs that are woven in the fabric of man's nature. These needs are as vital today as they were in the distant past. Scientists and economists may learn a great deal about the intricacies of natural processes and of cost accounting. But scientific knowledge of environmental management will contribute little to health and happiness if it does not take into account the human values symbolized by phrases such as the good earth, a brilliant sky, sparkling waters, a place of one's own. Furthermore, the increase in population densities and in social complexity inevitably spells social regimentation, loss of privacy, and other interferences with individual freedom, which may eventually prove incompatible with the traditional ways of civilized life.

Man can, of course, invent devices and techniques to minimize the effects of environmental pollutants; but he cannot protect himself against everything all the time. He is so adaptable that he can learn to tolerate many shortages and environmental insults; but medical and social experience shows that such tolerances eventually have to be paid in the form of decreases in the quality of life.

We might take comfort from the fact that during its long biological history, mankind has become adapted to many different kinds of environment and has been able to survive under very difficult conditions. However, these adaptive processes required thousands and thousands of years, whereas profound environmental changes now occur in the course of a few years—far too rapidly to allow for biological adaptation.

The fact that modern man is now moving into non-terrestrial environments might be interpreted as evidence that he has escaped from the bondage of his evolutionary past and is becoming independent of his ancient biological attributes. But this is an erroneous interpretation. The human body and brain have not changed significantly during the past 100,000 years and there is no ground for the belief that they will change appreciably in the foreseeable future. The biological needs of modern man as well as his biological capabilities and limitations are essentially the same as those of the paleolithic hunter and the neolithic farmer. Civilization provides man with techniques that greatly enlarge the scope of his activities, but it does not change his fundamental nature.

Wherever he goes and whatever he does, in tropical deserts or artic wastes, in outerspace or ocean depths, man must maintain around himself a microenvironment similar to the one under which he evolved. He can survive in outlandish areas only by functioning within enclosures that almost duplicate a Mediterranean atmosphere, as if he had to remain linked to the surface of the Earth by an umbilical cord. He may engage in casual flirtations with stars and other non-terrestrial worlds, but he is wedded to the crust of the Earth, his sole source of sustenance.

The strict dependence of the human organism on the narrow range of terrestrial conditions imposes inescapable constraints on civilized life. In practice, social and technological innovations are viable and humanly successful only to the extent that they are compatabile with the unchangeable aspects of man's nature. Man can retain his biological and mental health only if his civilizations maintain a healthy environment.

The phrase "health of the environment" implies much more than ecological equilibrium, conservation of natural resources, and control of the forces that threaten biological and mental sanity. Man does not only survive and function in his environment; he is *shaped* by it, biologically, mentally, and socially. To be "healthy" the environment must therefore provide conditions that favor the development of desirable human characteristics.

The very process of living involves a constant feedback between man and his environment with the result that both are constantly being modified in the course of this interplay. Individual persons, and their social groups, acquire their distinctive characteristics as a consequence of the responses they make to the total environment. The exciting richness of the human landscape results not only from the genetic diversity of mankind, but also and perhaps even more from the fact that surroundings and ways of life shape the biological and social attributes of man.

The New Pessimism

Scientists and technologists generally take it for granted that all aspects of their work enrich human life and make it healthier and happier. Confidence in the creative and predictive power of science is so great that several groups of scholars have now made it an academic profession to forecast the technological and medical advances that can be expected for the year 2000. Naturally enough, they predict spectacular breakthroughs in the production of nuclear energy, the development of electronic gadgets, the chemical synthesis of materials better than the natural ones, the discovery of drugs and surgical techniques that will keep men healthy or save them from death. From permanent lunar installations to robot human slaves

and to programmed dreams, many are the scientific miracles that can be anticipated for the year 2000. Individual scientists would differ as to what theoretical possibilities will be converted into reality during the forthcoming decades. But all of them would agree that scientific research is capable of providing very soon powerful new techniques for manipulating external nature and man's nature.

In view of the miraculous achievements of modern science, and of the promise of many more to come, one might expect the general public to believe that life in the near future will be safe, abundant, comfortable, and exhilarating. Yet, there prevails in modern societies—in particular, among educated groups—a feeling of uneasiness and even hostility toward science and its technological applications.

Most persons still trust that scientific research can increase the factual knowledge of man's nature and of the cosmos. Few are those who now believe, however, that such knowledge necessarily improves health and happiness. In fact, so many environmental values are being threatened by technological and social forces that the word "environment" has acquired almost a pejorative meaning which reflects public concern for the quality of man's relationship to the rest of creation.

Early in the 20th century, the physiologist L. J. Henderson developed the view that the natural conditions peculiar to the planet Earth are uniquely suited for the emergence and maintenance of life. In his classical book *The Fitness of The Environment*, he stated, "Darwinian fitness is compounded of a mutual relationship between the organism and the environment. Of this, fitness of environment is quite as essential a component as the fitness which arises in the process of organic evolution."

Today, the word "environment" is no longer identified with fitness, but rather with the biological and social dangers arising from modern life—such as the degradation of nature, the exhaustion of its resources, the effects of pollution, the behavioral disturbances caused by crowding and excessive stimuli, the thousand devils of the ecological crisis. For most laymen and not a few scientists, the word "environment" evokes not fitness but nightmares.

This atmosphere of anxiety, which has been called "the new pessimism" by Mr. James Reston in a *New York Times* editorial, has several different manifestations.

One is the feeling that science has weakened or destroyed many of the traditional values by which men function, yet has failed to provide a new ethical system. Science, the saying goes, gives man everything to live with, but nothing to live for.

Experience has shown furthermore that the advantages derived from scientific discoveries and technological achievements usually have to be paid for in the form of new dangers and new threats to

human welfare. The fact that nuclear science promises endless sources of energy, but also makes it possible to build ever more destructive weapons, symbolizes the two faces of the scientific enterprise. All too often, there exists a painful discrepancy between what man aims for and what he gets. He sprays pesticides to get rid of insects and weeds, but thereby kills birds, fishes, and flowering trees. He drives long distances to find unspoiled nature, but poisons the air and gets killed on the way. He builds machines to escape from physical work, but becomes their slave and experiences boredom. Every week the pages of magazines bear witness to the public's somber anticipation that the legend of the sorcerer's apprentice may soon be converted from a literary symbol into a terrifying reality.

The tactical triumphs and human failures of technological civilization call to mind the remark made to Hannibal by one of his officers at the end of the second Punic War, "You know how to win victories, Hannibal, but you do not know how to use them." No one doubts the power of science, yet a characteristic aspect of the new pessimism is the feeling that the most distressing social problems generated by scientific technology are not amenable to scientific solutions. Many are those who believe indeed that an environmental catastrophe is inevitable.

Fortunately, the word "catastrophe" can have two very different meanings, both applicable to the relationship between scientific technology and the future of the world community. In common usage, the word "catastrophe" denotes a disastrous event. In its etymological Greek sense, however, it means a change of course, an overturn not necessarily resulting in disaster. The disasters that threaten mankind are too obvious to need elaboration. But we can avoid these disasters if we keep in mind the etymological meaning of the word catastrophe and try to alter the present course of scientific technology.

In my judgment, scientists will contribute to the solution of the problems they create as soon as the scientific enterprise addresses itself in earnest to the present preoccupations of mankind. From this point of view, the technological breakthroughs predicted for the year 2000 are trivial and indeed irrelevant. They have no bearing on such problems as the raping of nature, environmental pollution, urban crowding, the feeling of alienation, racial and national conflicts, and other threats to decent life. The man of flesh and bone will not long remain impressed by the fact that a few of his contemporaries can explore the moon, program their dreams, or use robots as slaves, if the planet Earth has become unfit for his everyday life. He will not long continue to be interested in space acrobatics if he has to watch them with his feet deep in garbage and his eyes smarting with smog.

Despite our boasts, we do not truly *live* in an age of science. What we have done is to develop techniques for exploiting the external world, usually without regard to real human needs, and for

correcting a few disorders of the body and of the mind, often without much concern for the achievement of happiness. In many cases, we know next to nothing of the consequences—especially the indirect and long-range consequences—that eventually result from the manipulations of the external world and of man's nature, manipulations in which we engage so thoughtlessly.

Science and the technologies derived from it obviously exert profound effects on all human enterprises in the modern world. But we have not yet seriously applied scientific thinking to the creation of a desirable human life in the here and now, let alone in the future.

Focusing the Scientific Effort on Human Problems

When Rabindranath Tagore first arrived in Europe from India as a student on his way to England, he immediately sensed that the quality of the European landscape was a creation of human effort continued over many centuries. To him, the great adventure of European civilization had been what he called "the wooing of the earth." He saw in the European landscape a "great lesson in the perfect union of man and nature, not only through love, but through active communication."

Tagore's view of the human forces that have made the European land was rather sentimental and sounds antiquated. Yet the phrase "wooing of the earth" is ecologically more sound than the assertation that we must "conquer" nature. There cannot be "perfect union of man and nature" without some creative interplay between the two.

Man inevitably changes nature, and inevitably also he is changed by the environmental forces that he manipulates and to which he exposes himself. Human societies have always manipulated nature—clearing forests, plowing prairies, developing irrigation or drainage systems, then converting farm land into roads, dwellings, or industrial plants. The word "environment" now includes all the technological forces that modern man sets in motion, and that in turn shape his biological and mental characteristics. Sir Winston Churchill expressed this profound biological law in a picturesque sentence, "We shape our buildings, and afterwards our buildings shape us."

I shall illustrate with a few examples how the scientific enterprise can provide the kind of information that will help in maintaining the earth in a state suitable for the man of flesh and bone, and in creating environments favorable for the more complete expression of his potentialities.

a) Physicists have shown that nuclear technologies could provide mankind with an endless source of energy. On the other hand, any perceptive person knows that energy improperly used contributes to the degredation of the environment. The so-called "conquest" of nature by the use of any form of energy is potentially dangerous if

it conflicts with the imperatives of certain ecological laws. Tagore's "wooing of the earth" means the achievement of a state in which man, other living things, and the physical environment can all survive and prosper.

The wise use of nuclear technologies requires that we develop the kind of ecological sciences that will enable us to foresee the consequences of environmental manipulations, measured not so much in the terms of economics as of present and future human values. From this point of view, the creation and maintenance of sound ecological systems is more important than the "conquest" of nature.

b) Chemists and engineers will unquestionably produce more and more new materials and processes that will change many aspects of human life. It is commonly assumed that man can and must adapt to these changes. But in fact human adaptability is not limitless.

We know little of the thresholds and ranges of human adaptability. It is certain in any case that the ready acceptance of social and technological changes does not mean that these are desirable. Past experience has shown for example that ionizing radiations and environmental pollution (of air, food, and water) have deleterious effects that manifest themselves very slowly; they behave like the Pestilence that stealth in the darkness. Similarly, social and technological innovations that appear readily tolerated may eventually ruin the quality of human life. The real limits of adaptability are not determined by what can be tolerated for a certain period of time, but by future consequences. These consequences are essential factors to be considered in deciding what technological and social innovations are safe and desirable.

c) Medical scientists will certainly develop new techniques and new drugs for the treatment of the degenerative and chronic diseases that are now plaguing mankind. But such treatments will be increasingly expensive and more importantly will require highly specialized personnel. They cannot solve the massive health problems of the general public.

There is good reason to believe that most of the degenerative conditions that are becoming increasingly prevalent in the modern world need not have occurred in the first place. Greater knowledge of the environmental and social factors that cause disease would contribute much more to the improvement of human health than the discovery of drugs, surgical procedures, and other esoteric methods of treatment. Prevention is much less expensive than cure and always more effective.

d) Parochial man could theoretically be replaced by global man because technical procedures enable him to read, hear, and see anything that goes on in the world. But in practice communication technology is only a small part of the communication process.

We need more knowledge concerning the receptiveness of sense organs and of the brain to the information that technology can provide. We need to learn also how to make information become really *formative*, instead of being merely informative. Only those influences that are formative contribute to human development.

Pointing to some of the present inadequacies of science does not imply either a defeatist or an anti-intellectual attitude. It directs attention rather to the need for engaging scientific inquiry into new channels. The solution to our social and environmental problems is not in less science but in a kind of science which is subservient to the fundamental needs of man.

The Fitness of the Environment

Our societies are slowly realizing that many social and technological practices are threatening human and environmental health; rather grudgingly, they are developing palliative measures for some of the most obvious dangers. This piecemeal social engineering will be helpful in many cases, but it will not solve the ecological crisis and its attendant threats to the quality of life. Technological fixes amount to little more than putting a finger in the dyke, whereas what is needed is a comprehensive philosophy of man in his environment. L. J. Henderson's concept of the "fitness of the environment," quoted earlier, provides a framework for such a philosophy.

Fitness implies that man has achieved some kind of adaptation to his environment. Many populations in the past have achieved a tolerable state of adaptedness to their surroundings and ways of life, even when these were very primitive according to our own standards. But adaptive fitness lasts only as long as conditions are stable. Changes that upset the equilibrium between man and environment are likely to disturb physical and mental health and thereby to generate unhappiness.

More interestingly, fitness also implies that all aspects of human development reflect the adaptive responses made by the organism to environmental stimuli. In the long run, most forms of adaptation involve evolutionary alterations of the genetic endowment. But in addition, the biological and mental characteristics of each individual person are shaped by his responses to the environmental forces that impinge on him in the course of his development. Genes do not determine the traits by which we know a person; what they do is only to govern his biological responses to environmental influences. As a result each person is shaped by his environment, as much as by his genetic endowment.

The environmental influences that are experienced very early during the formative phases of development (prenatal and early postnatal) have the most profound and lasting effects. From early nutri-

tion to education, from technological forces to esthetic and ethical attitudes, countless are the early influences that make an irreversible imprint on the human body and mind. Most of the biological and mental characteristics that are assumed to be distinctive of the various ethnic groups—anywhere in the world—turn out to be the consequences of early environmental influences (biological and social) rather than of genetic constitution.

Human beings actualize only a small part of the potentialities they inherit in their genetic code, because these potentialities become reality only to the extent that circumstances favor phenotypic expression. In practice, mental development is greatly facilitated if the person—especially the child—is exposed at a critical time to the proper range of stimuli and acquires a wide awareness of the cosmos. Science and technology can play a crucial role in the shaping of mental attributes by making it possible to create environments more diversified and thereby more favorable for the expression of a wider range of human potentialities.

All men are migrants from a common origin. They have undergone biological and social changes that have enabled them to adapt to the different conditions they have encountered in the course of their migration; but as far as can be judged, all ethnic groups are similarly endowed with regard to biological and mental potentialities. This fact is of enormous practical importance because it justifies the belief that, given the proper opportunities, any population can shape its future and select the form it gives to its own culture, by focusing its attention on the biological, technological and social forces that affect human development.

The Collective Search for Knowledge

Programs of social betterment should be based on the ability to predict the effects that social and technological manipulations will exert on the human organism and on ecological systems, both the immediate and the long-range effects. Unfortunately, interest in scientific forecasting and planning has been concerned almost exclusively with the technological and social developments themselves, rather than with their effects on human life and on ecological systems.

Needless to say, there exists some factual knowledge concerning man's interplay with his environment; but it is a highly-episodic kind of knowledge, derived from attempts to solve a few special problems —for example, the training of combat forces for operation in the tropics or the arctic, the preparation of men and vehicles for space travel, the planning of river basins for water and land management.

Many scientific problems of relevance to human life in the urban and technological world cry out for investigation. Three examples will be mentioned here merely as illustrations:

a) Everyone agrees that it is desirable to control environmental pollution. But what are the pollutants of air, water, or food that are really significant? Sulfur dioxide, carbon monoxide, and the nitrogen oxides generated by automobile exhausts are the air pollutants most widely discussed. But the colloidal particles released from automobile tires and from the asbestos lining of brakes grossly contaminate the air of our cities and may well be more dangerous than some of the gases against which control efforts are now directed.

The acute effects of environmental pollution can be readily recognized, but what about the cumulative, delayed, and indirect effects? Does the young organism respond as does the adult? Does he develop forms of tolerance or hyper-susceptibility that affect his subsequent responses to the same or other pollutants?

Priorities with regard to the control of environmental pollution cannot be established rationally until such knowledge is available.

b) Everyone agrees that all cities of the world must be renovated or even rebuilt. Technologies are available for almost any kind of scheme imagined by city planners, architects, and sociologists. But hardly anything is known concerning the effects that the urban environments so created will have on human well-being and especially on the physical and mental development of children.

We know how to create sanitary environments that permit the body to become large and vigorous. But what about the effect of the environmental factors on the mind? All too often housing developments are designed as if they were to be used as disposable cubicles for dispensable people.

c) Everyone agrees that all citizens should be given the same educational opportunities. But what are the critical ages for receptivity to various kinds of stimuli and for the development of mental potentialities?

We must develop a science concerned with the effects that the environmental influences created by massive urbanization and by ubiquitous technology exert on physical, physiological and mental characteristics. We must learn how the effects of early deprivation or overstimulation can be prevented and corrected.

These three examples have been selected to illustrate that the environment must be considered, not only from the point of view of technology, but even more with regard to the responses that the body and the mind make to the surroundings and ways of life. And the same could be said, of course, for the responses of the total environment to technological interventions. The distant consequences of these responses both for human welfare and for ecological systems are the most important factors to be considered in scientific and social planning.

Few if any universities or research institutes, in this country or abroad, are equipped to deal effectively with the organization of

existing knowledge, and with the acquisition of new knowledge, relevant to the interplay between environmental forces and the world community. In fact, the use of existing knowledge, and development of additional knowledge, will certainly require a cooperative approach between institutions either at an international or a regional level.

Certain problems obviously involve the whole world community. For example:

a) Weather modification (Who will be deprived of water if rain is made to fall on a given area?)

b) Control of epidemics (How fast and along what routes does the influenza virus spread from one continent to another?)

c) The protection of endangered species (Certain species of primates are used on an enormous scale in American and European research laboratories; what should be done to prevent the populations of these primates from being destroyed in their countries of origin?)

d) Brain drain and related problems pertaining to the education and utilization of scientists.

Other problems are more regional in character. For example:

a) The technical problems of agriculture and conservation are completely different in tropical, arid, and temperate areas. Soil management, plant rotations, animal husbandry must be designed to fit the geological, climatic, and social conditions peculiar to each area. One cannot solve the problems of India by using knowledge and technologies developed for the conditions prevailing in Indiana.

b) Malnutrition may be due to shortage of calories in certain areas and to shortage of good quality protein elsewhere. The development of protein preparations that can serve as substitutes for animal and dairy products must be based on the kind of plant resources that can be economically produced. This in turn depends upon the geology and climate of the area under consideration.

c) A recent UNESCO conference urged the development of programs for monitoring pollutants in entire air sheds and water basins; but what pollutants? The chemical nature of air pollution on the United States' Pacific Coast differs completely from what it is in Taiwan or in Northern Europe. Water and food are polluted with microbes in certain parts of the world and with chemicals in industrialized countries.

d) Cosmic rays at high altitude, radio-nuclides absorption in areas of high radioactive background, marine chemistry and biology on different types of shore lines are but a few of the many examples of environmental conditions that may have great importance for different countries in a same region.

Global and regional problems, whether focused on man or on his environment, necessarily deal with complex systems in which several

interrelated factors interplay through feedback processes. The study of such multifactorial systems demands conceptual approaches very different from those involving only one variable, which are the stock in trade of orthodox academic science. Furthermore, this kind of study requires research facilities that hardly exist at the present time, and that few institutions or countries can afford. Hence, the need for the development of a collective approach in the mission-oriented institutions, either on a global or a regional level.

Fortunately, there is enough experience to feel confident that supranational scientific centers can function and be effective.

The World Health Organization (WHO) and its multifarious control and study programs; the World Meteorological Organization and its planned World Weather Watch constitute classical examples of scientific research and action on a global scale.

Even more promising, I believe, is the prospect for regional scientific centers. The Institute for Nutrition for Central America and Panama (INCAP) in Guatemala City, and the Satocholera laboratory in East Pakistan can serve as examples of regional institutions devoted to problems of health. The Centre Européen pour la Recherche Nucléaire (CERN) in Geneva, and the International Center for Theoretical Physics at Trieste illustrate what can be done for theoretical science. The success of these very different types of scientific institutes should encourage the creation throughout the world of other regional institutions focused on problems common to a group of nations.

The Universality of Mankind and the Diversity of Civilization

Certain general principles are valid for all environmental problems, because they are based on unchangeable and universal aspects of ecological systems, and especially of man's nature.

The biological and mental constitution of *Homo sapiens* has changed only in minor details since the late Stone Age, and despite progresses in theoretical genetics, there is no chance that it can be significantly or safely modified in the foreseeable future. This genetic stability defines the limits within which human life can be safely altered by social or technological innovations. Beyond these limits, any change is likely to have disastrous effects.

On the other hand, mankind has a large reserve of potentialities that have not yet been expressed. By enlarging the range of experiences and increasing the numbers of options, science and technology can facilitate the actualization of these latent potentialities and thus bring to light much unsuspected richness in man's nature and in ecological systems.

As more persons find it possible to express their innate endowments because they can select from a variety of conditions, society becomes richer and civilizations continue to unfold. In contrast, if

the surroundings and ways of life are highly stereotyped—whether in prosperity or in poverity—the only components of man's nature that can flourish are those adapted to the narrow range of prevailing conditions. Mankind becomes actualized to the extent that we shun uniformity of surroundings and absolute conformity in behavior. Creating diversified environments may result in some loss of efficiency; but diversity is vastly more important than efficiency, because it makes possible the germination of the seeds dormant in the human species. In the light of these facts, the continued existence of independent nations may be desirable even though it generates political problems, because the cultivation of national characteristics probably contributes to the cultural richness of mankind.

Diversity, however, does not imply complete permissiveness. Individual man must accept some form of discipline, because he can survive and indeed exist only when integrated in a social structure. Similarly, no group, large or small, can be entirely independent of the other groups within the confines of the Spaceship Earth. Total rejection of discipline is unbiologic because it would inevitably result in the disintegration of individual lives, of the social order, and of ecological systems.

In the final analysis, the interplay between man and his environment must therefore be considered from three different but complementary points of view:

a) The frontiers of social and technological changes are determined, not by availability of power and technical prowess, but by unchangeable aspects of man's nature and of ecological systems.

b) The total environment must be sufficiently diversified to assure that each person can express as completely as possible his innate potentialities in accordance with his own selected goals.

c) The expressions of individuality can be allowed only to the extent that they are compatible with the requirements of the social group and of the world community.

The universality of mankind, the uniqueness of each person, and the need for social integration are three determinants of human life that must be reconciled in order to achieve individual freedom, social health, and last but not least the exciting diversity of civilizations.

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