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44

SCIENCE AND TECHNOLOGY FOR DEVELOPING COUNTRIES

A Contribution to the Problem by the Pontificia Academia Scientiarum*

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SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

Culture and Science

The search for a new world order which will guarantee peace must be based on an adequate and well coordinated development of all nations, for as Pope Paul VI said in his *Populorum Progressio*, "the new name for peace is development".

The complete development of the whole man and of all men is identified with culture, with the development of all human capabilities, both spiritual and physical, by proportionately useful goods and services.

Science is one of the principal forms of the growth of the spirit; it has its own positive intrinsic values above and beyond the area of ethic indifference in which it is usually placed, for it is a well being of the intelligence, a well-being of man, which achieves knowledge of nature, verifies critically the truth of its findings, gives the spirit cause for rejoicing and provides a rule for practical applications which can be useful to man. It constitutes therefore a true growth of man, a perfectioning of the man-nature relationship. Every anti-scientific attitude, every limitation of the freedom of research is an obstacle to the perfectioning of man, a delay in the development of the man-nature relationship.

The Vatican II Ecumenical Council stated the principle of the legitimate freedom of science in relation to faith: "Systematic research in every discipline, if carried on in a truly scientific manner and in accordance with social norms, will never be really opposed to faith, because profane realities and the realities of faith originate in the same God. Anyone who tries to fathom the secrets of reality is guided though unaware by the hand of God, who, keeping all things in existence, makes them what they are. At this point may we be permitted to deplore certain mental attitudes, which some-

times exist even among Christians due to a lack of proper understanding of the legitimate autonomy of science, and which by causing disagreement and controversy, lead many souls to believe that science and faith are opposed" (*Gaudium et Spes*, n. 36).

Therefore it is obvious that the fact that science detracts somewhat from the supremacy of traditional theology does not automatically imply that it does not recognize the truths and the values of religion or the contribution that theology can make to culture and to man's progress in science.

This brings us to a point of primary importance: there exists in man an irrepressible need of knowledge in fields of thought which are only apparently contradictory but really, in the final analysis, in agreement. It is difficult to establish the principle of the two truths, the sacred and the profane, one theological and the other scientific. Truth is one, although it can be arrived at by different paths.

Science is not identical with all of culture; it represents a good, but a partial good, which must be integrated with other cultural values. The problem of the existence of two cultures, to which C. P. Snow refers, i.e., the scientific and the humanistic, must be solved bearing in mind their diversities within the unity of knowledge. We must avoid not only the danger of their separation into mutual ignorance and exclusion but also that of identifying one with the other, and particularly, today, the reduction of humanistic culture to scientific culture.

Whoever in any way promotes scientific development must understand its inevitable relation to humanistic culture, must understand that the intelligence is not limited within the boundaries of phenomena but is open to the vast horizon of the intelligible. Culture which is exclusively scientific limits the boundaries of knowledge, atrophies by its method and its language a part of intellectual energy, renders the intelligence incapable of following other paths which are not scientific, of moving about in transcendental fields. Scientific culture, when it abandons its isolation and integrates itself with humanistic culture, brings to the latter great benefits. Scientific reasoning, on the other hand, which has its own discipline, strengthens the rationality of thought in other fields

of knowledge, resists the temptations of rhetoric and orients one toward more positive proofs. Experimental research orients the intelligence to a keener observation of human events. It should also be noted that collaboration in scientific research, whether within individual nations or in the much broader limits of the world community, can create solidarity among individuals and nations in protecting human rights and preserving peace.

Science and Technology

Technology is a part — or a phase — of science and actually can be considered an operational aspect of science, so closely related that it is difficult to differentiate it from science. Therefore it is reasonable to maintain that technology *is* science, and not just a passing moment in science.

Thus science and technology cannot be opposed to each other but are very closely related aspects of the same phenomenon, just as, for example, thought and language. In fact, as it is conceivable that an idea exists but is not expressed, so there can be a scientific moment without its technical expression, but just as language expresses an idea — or, if you will, is given content by thought — so technology requires science, with which it forms a complete whole. And thus technology has the same relation to science — Saussure might say — as language has to speech.

Although science is not without its own particular structures, represented by the methods of the individual disciplines and by the principle of complementarity, technology appears much more articulated, almost on different levels, and has, so to speak, one structure which is methodological and another structure depending on the field where it operates or, perhaps particularly, on science and government.

The roles of science and technology should thus appear more clearly defined: science (and with it technology) tends to transform man's concept of the world, with knowledge as its objective; technology participates in this transformation by producing techno-scientific innovations in the social and environmental context.

Technology serves man's needs. The quantitative as well as the qualitative development of technology depends on anthropology in the course of history that is, on man's image and the projection of his cultural progress in each era under the influence of philosophy, of science, of art, of political and social movements. The tools sought by technology depend on the image of man, of his aims and needs that each civilization or society has achieved. And since man's needs concern his *being* as well as his *having*, technology develops in accordance with the cultural being-having model that is provided for him by custom and by the social-political forces.

If on first analysis, science and technology, based on a widespread prejudice, appear unconcerned with political choice, it is obvious that choices, programs and realization must be judged in a context in which society is both subject and object at the same time. Social needs are the foundation for choices which require and determine scientific-technical action. The latter must bear in mind the reasons for the choices and must participate in the programming of the choices, in the selection of means and in the realization of tbe objectives.

These tasks, on the scientific level, are accomplished by technology. Scientists and technologists participate in modifying the models of action by preparing both the conditions for the choices and programs and the means for their realization.

Thus the problem of a hypothetical domination of science over politics takes on a more precise shape, but actually we should call attention to the many ways in which politics dominates science.

The proper relationship between being and having requires the subordination of *having* to *being*, of the control and use of goods to the improvement of the values which constitute humanity both as individuals and as a society. The reversal of this relationship by subordinating beings to possessions through the indiscriminate subordination of man and the community to production limits man's life and development with regard to his highest spiritual values, even destroys freedom and privacy and favors the formation of political and economic totalitarianisms.

Technological programming always implies limits which must be well understood. In the first place, the technical program may

indicate the means only, never the objectives; the latter are proposed by humanism, which includes the spiritual, ethical, cultural, social and civic values of the whole man and of all mankind. Technical programming derives from all of humanism its human content, which it must serve with the proper quantity and quality of means. In addition, technological programming must be well aware of its temporal limits, because of the continuous progress of science (which requires always new technical procedures) and of the turning points in the history of humanity as it expresses new needs.

So all technical programming must be subordinated to man's true values, to the progress of science of history, and therefore it must understand its own temporary nature and must always stand ready to serve.

The fact that technology has been uncontrolled in deciding the quantity of the means — which emphasizes the supremacy of *having* and can be easily manipulated by economic and political power — has dominated the applications of science and caused great difficulties, for science must follow a qualitative path even though it uses quantitative means.

Technology and the Third World

The prevalence of purely technological effort in the third world is due to various factors, such as the desire of the decolonized nations to copy the model of civilization of their ex-colonial masters or of their new friends, the expansionistic drive of the industrialized countries toward new foreign markets in an effort to have their national development equal their industrial development, and even more the illusive hope of expressing econometrically the relation investment-profit in numerical terms by poorly understood formulas such as those of Cobb-Douglas.

As a result the parameters of development have been developed and popularized without an in-depth analysis to point out their limitations. Such is the case of the so-called "Gross National Product" per inhabitant, taken as an index of national progress. And

so, despite these developments, the applications of science are responsible for the distance which separates rich countries from poor countries, a distance which is growing greater every day, even though in many of the poor countries there has been an increase of the gross national product many times greater than the minimum considered desirable: the rich grow richer every day. In other words, the increase flows back mostly to a part of the population which is socially and politically privileged.

All this is reflected in the anti-scientific attitudes and the series of social manifestations which since 1968 have been attacking the so-called "establishment", that is, the ruling class, without knowing what to substitute in its place.

The United Nations conference on the application of science and technology to development, held in Geneva in 1963 with 1600 representatives, most of them from the industrialized countries, saw the emergence of two tendencies in the contribution of science and technology to nations. The first, based on an increase in scientific applications favorable to economic development, that is, in *having*, were received with greater emphasis and zeal. This is the scientific-technical road which follows very definite lines, with pre-established coordinates in search of an economic benefit dear to technocrats and many political leaders. The second tendency stresses rather the promotion of "*being*", and therefore the importance of education at all levels, the creation and formation in the developing countries of indigenous knowledge, stressing the elements which can best satisfy the aspirations to an improvement of the human condition, that is, education, knowledge, health, nutrition, transportation, housing and the adjustment of work techniques to the socio-cultural conditions of each nation, thus creating a truly effective social development.

Scientific Information

A wider dissemination of scientific information at all levels — from the most limited and specialized to the broadest popularization — eliminates isolation and permits the control by society

of the contribution of science to politics and also the use that politics can make of science. Of course such a solution presents difficulties for it presupposes not only the elimination of long-established prejudices, but also the possibility of effective communication with the people and public opinion without any need for manipulation.

To the objection that our society is conditioned by the mass media and that the various means of communication furnish information of interest in all possihle areas, one might reply that it is precisely the *quantity* of information that limits its quality and ability to inform. And this, naturally, without mentioning the fact that man is submerged in a sea of information and news not always — in fact rarely — useful to the recipient, not only because of frequent deformation but also because of intentional incompleteness which results in actual distortion. In spite of all this, information is still the raw material for anyone who must and wishes to be a part of society.

The problem of communicating and informing, with all its possible solutions, involves risks which are of considerable importance in a democratic society. In this connection it should be pointed out that communication — aside from all description or clarification that is strictly technical — takes place in the meeting between informers and informees, that is, those who disseminate and those who receive the information.

This problem which arises in the political and social fields applies also to the field of science, where the desire to communicate should have as its aim participation. This communication-participation can touch two levels, different but both equally important:

(a) Communication among specialists.

By its nature scientific data requires preliminary knowledge which is not always generally available to everyone. The first information becomes a sort of stimulant to the mind of others, beyond the purely informative. It is almost like an appeal launched to a certain group from which one expects replies, criticism, confirmation or refutation. This function is performed by scientific publications, whose degree of specialization is determined by the type of reader to whom each is addressed. Then there is also the function of

keeping us up to date, of information in the strictest sense, precisely that which is defined as "scientific communication".

(b) General communication.

It is important also for political-cultural reasons, that the public should overcome its distrust of science.

The distribution of educational data, or popular information of a scientific character tends especially to decrease ignorance, to raise the level of general culture, to dispel mistrust and preconceptions, that is, it teaches us to be rational, to reason logically, to dispel fears and illusions, thus obviously promoting progress in general and a more adequate participation in society, which often conceals its lack of scientific knowledge.

Mutual Respect and Dialogue between Cultures

What must prevail above all in every country is the promotion of its own culture, which must be integrated with science in its many modern aspects, so that consequently there will not be separate policies of action, such as cultural, scientific and economic, carried out by its planners.

The all-inclusive definition of culture is valid for all nations, and includes the old and the new, history and tradition, customs and usages, and it is particularly necessary for nations who have recently acquired independence in order to preserve their own national characteristics.

Every human group — which for convenience we may here consider synonymous with "nation" — has developed its own concept of nature and of the world, has established the goals it wishes to achieve, with its table of priorities, and has set up norms for individual and collective conduct, based on conditions of climate, geography, history, economics, religion and general culture.

The scientist cannot ignore the group in which he was born and by whose ideas he has been formed, not only because belonging to a specific country precedes and is independent of any professional choice, but also because of the influence that that particular system of values, language and traditions has had in his formation. All his

life will be influenced by the cultural heritage of his country, which he has in common with all his countrymen.

Science has always been based on a national culture and a national scientific community, and its international character is due more to its theoretical objectives than to its origin. History proves in fact that science has never been free from the effect of national factors, but the science of one country has always been a guide to others. At the beginning of modern science Italy was regarded as a leader, then France and England, and later Germany; today it is the United States and Russia.

In a culture science and technology, although they use universal methods, will have no value if they cannot have a national identity of their own, which must in each country be integrated with the social development of the country. And so it is important to introduce the teaching of the sciences, especially in the developing countries, from the very first school years, for the recognition of ecological values and the creation of a spirit of observation and critical elaboration of thought, certainly not for repetitious and cumulative learning that cannot lead to the formation of a scientific humanism, which should be the true objective of modern education.

To preserve the culture of each nation and to develop it in a way that is conducive to true progress for civilization, we must avoid all forms of colonization, not replace political with scientific-technological colonization. Therefore the scientific-technological set-up in each country of the Third World must be made autonomous so that progress can be made toward scientific collaboration among all the nations of the world.

Indeed it is not possible to conceive of the international community except as an ideal center in which all the countries of the world come together, thus creating a group of national scientific communities. A country that is scientifically backward, cannot become a part of the world scientific community and will always be regarded as inferior, or backward.

Cooperation among nations requires that the more developed nations honestly warn the developing countries against the errors and the harm that have been caused by the undue predominance of scientific-technical activity over man's other activities, with the resulting serious cultural disequilibrium and disregard or loss of

fundamental human values and the irresponsible exploitation of nature which have disturbed the ecological equilibria. In particular, the experience of the technically developed countries must help the other countries to understand what is the harm to culture and to human society caused by internal migrations, by certain types of urbanistic expansion and industrial development, by abandoning the land and leaving it open to industrial exploitation, by the abuses of technology with the disturbance of the natural cycles and resulting dangers for the whole world.

It is important that science and technology, which have been developed to such a high degree in Europe and in North America, should not destroy with their striking power the civilizations of the countries of the Third World. *Gaudium et Spes*, after having noted that our age has need of wisdom and that "the future of the world is indeed in danger, unless we produce wiser men", goes on to say: "It should be noted that many nations, economically poorer than others but richer in wisdom, can offer valuable help to others" (n. 15). The western world, which is scientifically advanced, must therefore not take a position of pride and superiority for it can receive much that is qualitatively superior from countries that are technically less advanced.

The help that countries which are scientifically and technologically more developed can give to countries which are backward in this regard, must be based on mutual respect and dialogue between their cultures. Through cultural dialogue, reciprocal benefits and faith in each other can be achieved, thus avoiding predatory acts on the part of some civilizations by the imposition of their technology, as has unfortunately occurred in the past and still continues.

Scientific research, while it must in the pure state have complete liberty in the choice of its area of research, must also be oriented toward research which appears more favorable to general cultural development and can lead to the elimination of the poverty existing in certain nations, and to victory over the challenge to man from certain natural phenomena, from disease, from long-standing unjust social customs. Scientific-technical programming for the development of the backward countries must be based on an understanding of their culture and their history, and must be carried out by learned men who are able to combine science and wisdom.

Technical Assistance from Developed Countries to Developing Countries

Scientific-technical collaboration intended to orient and achieve the development of less developed countries requires for as long a time as necessary assistance from the more developed countries, collaboration of the capital and technicians of both sides. The industrialized countries must help the poor and the very poor countries, where two-thirds of the world population lives, for spiritual reasons regarding human solidarity, and also because without the help of the industrialized nations to the poor nations there can never be peace, which is of supreme interest to all, nor can man achieve survival in the tranquillity of a modest material life.

Science and technology must contribute to such a program. Rather than bilateral assistance, projects should be set up which are directed by international organizations, whose effectiveness cannot yet be completely proven because of the lack of means at their disposal in comparison to the greatness of the problems which they must solve. We must avoid all political manipulations in governmental organisms of the participating nations, for what happens is that when the meager financial means available are divided among the various projects, it becomes impossible to achieve anything more than superficial results. We must especially protect the developing countries from exploitation by the multinationals.

The experts from the industrialized countries who are to give technical assistance must put in practice the wise words addressed to them in the *Populorum Progressio* (nn. 71, 72): "Always more numerous, we are happy to say, are the experts sent on development missions by international or binational institutions or by private organizations. They must not act as owners but as assistants and as collaborators. A country quickly realizes whether or not the help they bring is given with love, whether they have come simply to try out techniques or to allow men to realize their true worth. Their message is in danger of not being accepted if it is not given in the spirit of brotherly love. The indispensable technical competence must be combined with the true signs of disinterested love. Without nationalistic pride or any hint of racism, the experts must learn to work in close collaboration with all. They must understand

that their competence does not give them superiority in all fields. The society in which they have been raised undoubtedly has elements of universal humanism, but it is neither unique nor exclusive, and it cannot be imported without certain adaptations. Those who are responsible for these missions must take care to learn, together with the history, also the cultural characteristics and heritage of their host country. Thus there will be created a collaboration which will benefit both civilizations.

Transfer of Basic Science to the Developing Countries

Basic science must be promoted in the developing countries. It must never be assumed in any country that too many things have already been discovered and that it is necessary only to develop the technological applications. In the underdeveloped countries the promotion of basic research, pure or oriented, is necessary not only to avoid scientific and technological colonialism but also to build technological plants that do not cause destruction of the culture and nature, and also to develop formulas of technological innovation which are economically valid.

The importance of basic research is felt in all fields of science. For example, in the field of molecular biology, which has extended its sphere to a knowledge of the specificity of cellular receptors and to the interpretation of antigene-antibody reactions. At the same time new perspectives are opening up in the transmission of biological activities with the interpretation of the effect due to the "messengers nucleosides", and cell-to-cell transplants are being made in cellular and subcellular organelles. This requires a change in the classic concepts which were once regarded as immutable, and it indicates that a new era has begun. On top of all this we now have genetic engineering, which so gravely preoccupies science.

Thanks to the knowledge acquired by molecular biology in the *Eucariota*, we can now transfer to the vegetable world information which seems to indicate that we can overcome the apparent impasse at which we have arrived in food production or the use of non-conventional foods, a problem which is of the greatest concern for

the modern world, as seen from the results of the United Nations Conference in Rome.

In principle, the transfer, or teaching, of science has no limitations except the individual's capacity to learn and the availability of teachers.

Therefore it is a problem which interests a limited number of individuals and involves limited means. There are two poles of reference for judging the validity of scientific transfer: the international scientific community and the local scientific community. The first is a completely open system, comprising both national and international institutions (Universities and Research Centers) which one can join or have access to and thus contribute individually to the general development. In the developed countries this occurs mainly within their own institutions, in the developing countries through the study abroad of young scientists. Many countries in the latter situation consider it a net loss of talent, losing sight of the fact that many of these talents would not have developed under different conditions and that everyone has the right and the obligation to find out how he can develop his talents to the highest possible degree and best contribute his ability to the development of the international scientific community.

The problem is not that of preventing the so-called "brain-drain", but of how to utilize the successful entry of certain individuals into the international scientific community for the prestige or benefit of their own country, and the influence of that prestige in other areas of foreign relations, and above all, to recuperate them partially as cultural liaison operators and as intermediaries, even possibly to some degree as teachers.

The other pole of reference, the local scientific community, requires a more detailed study because the effectiveness of scientific transfer implies not only the ability of few individuals who have become part of a society which will allow them to develop to the maximum, but also the creation in the developing countries of structures which can be maintained, multiplied and especially modified in accordance with world scientific evolution. Here the choice of scientific field is a decisive factor, and thought must be given to how much it is desirable and possible to accomplish in the technological field for the country's development.

Technology and Choice of Scientific Field

In effect the transfer of technology is subject to the greatest limitations and conditioning because there does not exist an open world technological community like the scientific one, but innumerable separate technological worlds, separated and conditioned by powerful economic interests.

Moreover, the transfer of technological knowledge is subject to the following limiting conditions:

(a) It is an operation that has no value if is not followed by important technical and definitely productive achievements.

(b) It is an operation which is generally not of brief duration and very often subject to rapid obsolescence.

Often it produces debatable economic and social results. Some of these handicaps can be overcome if there is an adequate scientific base which makes it possible to evaluate the transfer operations with respect to: actual validity of the technology, the possibility of foreseeing the period of obsolescence, recognition of the possible innovative developments and an assessment or an awareness of subsequent research needs.

All this shows how important it is that the choice at local level of scientific field be related to the technological one and positively productive. However, the choice at the scientific level is a choice of a broad field whereas the technological choices are more precisely limited to specific problems or topics, and the relationship between the two must not be pushed to the point where they lose their separateness and their specific nature.

The scientist is a scientist, and the technologist is a technologist, but they can both move along the same lines and help each other reciprocally.

An example can perhaps clarify this. A country which has a great interest in fishing and wishes to adopt the most advanced technology in this field can start a development which is interesting and not isolated if at the same time it carries on scientific activity in physical and biological oceanography, for example, combined with international telecollection of information, pledging itself to

furnish information regarding its waters, organizing and operating a data-bank on local marine production, carrying on certain campaigns for the sea, assisting operators with forecasts, appraisals and other information.

A country that is predominantly agricultural, especially if it has one or several important monocultures, and wishes to improve and perfect these technically, will certainly benefit from a choice of scientific field which aims at genetic improvement and the biological control of insects.

In this case, rather than a transfer of technology what occurs is the development *in loco* of those technologies, and that country's need will be predominantly of a scientific nature.

A country which has a widely diversified established structure and which is interested in local sources of energy, for example solar energy, can certainly make this transformation effectively if for example its scientific choice is climatology.

Or, again, a country which realizes that its development lies in the development of its mineral resources will certainly benefit if its choice of field is oriented toward earth science, chemistry, geology, etc.

These are only examples, very schematic, but they are based on a fundamental principle. That is, a country must begin with a good knowledge of itself and of its own possibilities, of its natural and human resources and the cultural heritage at its disposal. If a profound cultural transformation is to be made, this must be carefully evaluated with all its consequences, beginning with very precise information, with an accurate knowledge of itself and of the possibilities of its transformation.

The conclusion we may draw is that the transfer of science and technology for development cannot be defined in general terms but each case must be studied individually.

The type of development which a country wishes to achieve will determine the type of technology it must acquire and will also orient it toward the proper choice of scientific field in local terms. A hookup with the international scientific community is essential in order to avoid isolation. Every realistic plan for development must be based on a profound knowledge of oneself, of one's territory, of the natural and the human resources available.

The Relation between Risk and Benefit

The installation of science and technology in the developing countries obliges them to study and solve the risk-benefit relationship, which is found in every human undertaking, and particularly in the scientific-technological adventure. The analysis of risks and benefits can be used for anti-scientific ends, for political or emotional purposes; no other type of investigation has caused such a reaction or produced so much hostility toward science as has this form of evaluation. On the one hand we have those who, defending the individual as an untouchable element of society, are not satisfied with a pseudo-security based on the probability of statistical data; and on the other hand are those who, with the same data, base the evaluation of social progress on the predominance of the average individual as representative of the whole of society.

This risk-benefit criterion, an example of which is the probable relation between smoking and cancer, originated following the indiscriminate use of pesticides and was subsequently extended to environmental problems. Today it is at its most crucial stage, with the spread of nuclear power plants and research on genetic engineering.

The case of DDT and other pesticides is significant. It arose when it was discovered that DDT is toxic to man, and then came the terrible dilemma whether to continue its use, which is indispensable for plant and food production in the Third World countries, or to stop using it completely. In recent years the first alternative has prevailed by far, as it was considered necessary and, despite its inhuman aspect, more likely to save lives than the second.

The problem of the spread of nuclear power plants is perhaps even more difficult because of the greater complexity of the risks, from which are not to be excluded sabotage, acts of terrorism, functional accidents. However, the energy requirements seem to justify in some cases the use of these reactors.

The question of genetic engineering, which has caused great controversy in the United States, is even more controversial and crucial. Here we have an advance frontier of science that has barely been reached, which at the same time is of practical interest for it

is useful in modifying some lines of technological application as well as in opening up some most interesting biological perspectives.

The answer to the concern caused by the risk inherent in almost all scientific and technological progress and an evaluation of the benefits which this progress can bring might be given by science itself. It is not by chance in the field of pesticides that new methods based on new principles are being sought to provide plant protection and the defense of agriculture against insects and disease. The recent Study Week organized by the Pontifical Academy of Science pointed out a number of possibilities, among which are those which do not cause pollution of the environment and which can reduce the damage caused by the use of persistent pesticides: the use of pheromones, of juvenile hormones and of specific viruses was discussed, as well as the possibility of producing plant resistance to disease through the formation of phytoalexins, and strict methods for their use were prescribed.

SCIENCE, TECHNOLOGY AND NATURE

Science and technology must approach nature in a spirit of creative collaboration. Nature, that is, everything material and corporeal that exists, seems to have two limitations: incompleteness and degeneration.

Nature is "incomplete" or unfinished as it is always open to new developments, through a combination of its energies. Moreover, it is subject to disease and death, to loss of energy and to destructive clashes between opposing forces.

Confronted with the incompleteness and the degradation, man, both the scientist and the technician, must use his intelligence to coordinate, animate, appropriate for his own benefit the forces of nature and to counteract its degenerative processes.

However, if it is man's ideal task to perfect the work of creation and to combat degeneration, his action is often insane, as it has been in the past and is still today in our age of technological progress and industrial civilization. In fact, man wants above all to dominate nature and to exploit it, impoverishing it, in order to increase production; thus he is creating new and dangerous processes of degeneration.

Technology and industry are responsible for having almost eliminated in the Western World the inclination and the very aptitude for contemplation, so greatly does the myth of production absorb the energies and the time of western man. It is important that among those people of the Third World who still have the contemplative ability there should be established a proper relationship between technology and nature, so that the artificial does not suffocate the natural but preserves and perfects it so as to enrich it for the enjoyment of the spirit.

For the spiritual health of man it is important that in every country a well-balanced and harmonious relationship between tech-

nology and nature should make possible not an absolute domination but a beneficial management of creation, so that man can enjoy a fraternal relationship with living beings and with material objects, thus repeating the *Canticle of Creation* of St. Francis of Assisi.

An example of the worldwide necessity to limit man's control over nature, in order to obtain an immediate profit without consideration of future consequences, is found in the exploitation of the tropical forest.

The area covered by tropical forests is approximately twenty million square kilometers and represents about 50% of the entire world forest area. About half of the presently existing tropical forest, distributed in varying amounts throughout the various countries, can still be considered to be intact, that is primeval. Its survival, however, is today in all countries seriously threatened, especially by speculators, industrialists, etc., who see in the tropical forest a useless natural formation, easily put to use, which can be replaced by cultivation producing an annual profit, with plantings perhaps even of forests which give more frequent periodic earnings. This narrow and egoistic mentality, and the private interests of a small minority have led to the destruction of enormous forest areas throughout the world, upsetting the socio-economic equilibrium of whole populations and making a desert of entire regions.

The most outstanding characteristic of the tropical forest is its extremely rich composition of so many species which live together in perfect biological equilibrium of the ecosystem. This equilibrium is the result of the interaction of many elements over thousands and thousands of years. It has made it possible for the forest in all its complexity to overcome the environmental adversities and natural catastrophes which occurred during its formation. The basis of this biological equilibrium, and in fact of its preservation, is dependent on maintaining that recycling of substances through which the forest on the whole restores to the land in organic form (leaves, fruits, branches, etc.) all that it has absorbed from the earth in inorganic form. This accumulation of organic matter on the forest floor is rapidly attacked by the microorganisms which break it down, degrade it and thus refurnish in the form of mineral elements the nutritional resources for the forest. This complex and marvelous biological cycle cannot be interrupted by man's taking from it

— except in modest quantities and in such measure as can be compensated by the forest's growth — without running the risk of profoundly upsetting the biological equilibrium. It is obvious that the removal of considerable quantities hinder the restoration to the soil of organic substances and mineral elements and thus there is a progressive impoverishment of the nutritional sources and a dying out of the forest. The removal of a great number of plants from the ecosystem causes ecological and biological disturbances. The penetration of greater light into the forest interior and to the soil causes abnormal evaporation of the ground moisture and accelerates the photosynthetic processes, to the detriment of plants, which make up the layers of vegetation underlying the upper part of the forest; this causes the germination of many seeds and the growth of plants which normally could not develop without light in an uncontaminated forest. The action of the wind, which thus penetrates more forcefully into the forest, causes turbulence and alterations.

From all this it may be easily understood how the simple removal of a plant, or the creation of a void in a uniform forest growth can cause changes which far exceed the immediate local harm.

The complexity of the tropical forest, composed of various strata of vegetation, is such that it is extremely sensitive to every change. It has been calculated that about 42% of the precipitation on a tropical ecosystem does not reach the soil but is stopped by the vegetation and returns by evaporation into the atmosphere. This is of great importance in the climatic regulation of the tropical areas. In an altered ecosystem a greater percentage of water reaching the soil causes uncontrollable phenomena of streams forming, with great changes in the hydraulics of the soil, the carrying away of the topsoil, of the fertile layer of the soil, etc. Penetration at a particular point of the forest, even of a limited area, naturally affects vast surrounding areas through the network of streams that is thus formed. This also occurs when the natural forest is replaced by an artificial forest, and even more in the event of agricultural cultivation. In the latter case, the impoverishment in the nutritive elements of the soil due to failure to replace the organic substance because it is removed by man in the form of agricultural products, is accompanied by a bleaching of the soil, which has become less stable because of cultivation and of the lack of a protective layer of topsoil. In these

tropical soils, agrarian cultivation is thus destined to a short life because of the rapid impoverishment of the soil. Moreover, the chemical-physical and microbiological changes that occur in the soil as a result of cultivation make a spontaneous regrowth of the forest difficult.

Cultivation produces profound changes: just think for a moment of the symbiotic microflora, which is completely replaced by the new plant cultivated. A restoration of typical symbionts of the tropical forest becomes difficult, especially because of the altered general pedological and microbiological conditions. Under these conditions it is much more probable that the areas involved are destined to become a desert in a short time.

The primary tropical forest has a capacity for the storage of solar energy and for evaporation superior to any other forest or agrarian form we know. Therefore it can be replaced only by reproducing exactly that particular environment, avoiding excessive number of plants per surface unit, as well as underpopulation, which would cause the problems already mentioned of hydraulic deterioration of the soil and the ecosystem in general. In any case, the transformation of the primary tropical forest into rapidly growing plantations in order to obtain a periodical wood crop can only lead to an impoverishment of the soil, which cannot be compensated by the application of fertilizers. The latter, together with the already serious climatic and biological disturbances as well as the changed water balance of the soil would alter still more profoundly and permanently the pedological conditions and so upset the proper development of microorganisms in general, and in particular of those that make up the nitrogen cycle, as well as the Mycorrhizogenes.

With the transformation of the primeval tropical forest into an artificial forest or into agrarian cultivation, the total annual rainfall does not change. However, the distribution of the rainfall is profoundly altered and rain falls also during the period when the vegetation uses or needs very little of it, thus causing profound alterations in the general climate of the zone. Moreover, we are not certain what the effect the deforestation of great areas of tropical forests like the Amazon basin would have on the world cycle of oxygen and carbon dioxide.

All this makes clear the tremendous importance of the primeval

tropical forest. Naturally, however, this does not exclude man's presence in the forest, and his partial utilization of it, provided this is done in accordance with proper norms which will guarantee its conservation. In the southwestern part of the Ivory Coast the local population lives practically from the forest; but, in accordance with a millenary tradition which has been adopted by all primitive peoples, they take reasonable measures to preserve the forest. In fact, among these people agriculture of the so-called nomad type affects small areas in the interior of the forest. The soil is prepared after the smaller plants and the underbrush are removed, but the taller plants remain, as they are important hecause they do not expose the cultivated areas to excessive rainfall or sun and they guarantee that the forest reestablishes itself after the cultivation is ended. The earth is cultivated for several years, then it is abandoned and adjacent areas are cultivated. By this technique the soil, after having been cultivated, is automatically taken over again in a short time by the forest, without serious danger of alteration of the soil or of the environment.

Soil in the tropical forest is extremely important. It cannot be replaced by other vegetable formations without the risk of causing enormous disturbances in the biological equilibria of local and world ecosystems. The primeval tropical forest is the natural expression of the environment in which it has grown through thousands of years of interaction with all the factors of the ecosystem. The characteristics of the tropical soil and its influence on the general conditions of the area make the forest irreplaceable and a source of life for the local populations

LAND MANAGEMENT

The existence in cities of industries and thus a source of labor, and the conditions considered necessary for social well-being (social services, schools, hospitals, recreation facilities) have created in the whole world, and especially in those countries which have recently become independent, a migration from the country to the urban centers.

This has led to the growth of abnormally crowded centers where, because of the very speed with which this happened, it has been difficult to provide suitable and adequate housing, hygiene and sanitary facilities, schools and even work, which had been the *primum movens*, the prime reason, for these migrations.

All this causes poverty, disease, hunger and, at best, dangers for the morality and health both physical and mental.

In the view of the Holy See it is urgent to utilize here the findings of science and technology in order to offer alternate solutions for the welfare of the people.

In modern urban development of the western type and later of the developing countries, the cities have grown, following the logic of having more and consuming more.

In reality the growth of the cities has brought wealth to the citizens who were already well off, the workers in a privileged class, clever and dishonest exploiters, but at the same time it has created in the historic centers and the suburbs continually increasing poverty and misery.

For everyone the quantitative growth of "*having*" has led to the impoverishment of "*being*", that is, a determination in the *quality* of life.

The need now arises for a new kind of urban planning for a new type of cities through the creative and responsible participation where possible of all citizens. The consumistic idea of having more

in order to enjoy more must be replaced by a more evolved idea of creating together a new society in which the "having more" (that is, the greater wealth) is more widely distributed through new forms of socio-economic organizations in behalf of universal "being more", which means more over-all distribution of well being.

Cities for man's well being must favor more particularly the weak, the children, the aged, the handicapped, those who are growing up to manhood or declining in old age but who are nonetheless human beings from the civil and human point of view. A city which ignores these categories of men or neglects them grows poor in human and civil values and becomes always more closed in by the miserable and wretched culture of production and consumption.

Plans for cities where everyone participates are necessary, cities where there is room for infants, children, young people, where families find their congenial environment, the aged find a listening ear, and the handicapped find necessary and spontaneous assistance.

Cities for man's well being must promote the creation of smaller groups or nuclei in neighborhoods and zones where tbose human energies which are usually suffocated can develop and integrated community solidarity is created. Also they must provide space for the most varied cultural activities, favorable to human physical growth as well as intellectual, artistic, economic, social and political development.

In the spirit of the declaration *Dignitatis humanae* of the Second Vatican Council, the city must promote religious freedom, excluding any undue interference and favoring with equal time the free expression of every legitimate religious cult.

Secularization, which guarantees autonomy for secular, non-religious activity, must not degenerate into secularism, which organizes social life in such a way as to eliminate all possibility for the public expression of activities which are not secular, thus depriving human beings of the right of association and public manifestation for any spiritual initiative.

It is not only a question of scientific and technological problems but of the creation of a more just society by raising the living standard of nations and thus guaranteeing a life with dignity.

Planning of Urban Development

The planning of a new city could today be achieved by using parameters based on mathematical models which can assure the best solution: a minimum amount of pollution, ease of transportation, adequate park areas.

These modern planning technologies will have to be adopted in the planning of *new* settlements, whether these be neighborhoods or satellite cities as is happening in some instances. Yet the more complex problem is not the planning of a new center, but correcting the evils and the unfavorable conditions caused by chaotic unplanned construction which have produced absurd megalopoles. Solutions must be found to decentralize these settlements, to create production centers in surrounding areas, and to rehabilitate the slum areas.

Planning of Industrial Areas

Industrial areas are a measure of the economic progress of a nation and should therefore be encouraged. But in that case countries which are in the process of becoming industrialized should adopt the most advanced solutions, avoiding the negative phases through which industrialization has gone in the last century, and thus protecting the health of the workers and the environment.

Therefore industrialization must be provided for, in collaboration with the developing countries, by adopting "clean" technologies and not, as has so often happened, by transferring production systems which are highly polluting and which take advantage of the lack of legislation in these countries and their desire to become industrialized at all costs.

It might be desirable to plan for the dispersal of industry throughout a territory so as to avoid concentrations. It is also important in the settlements to bear in mind all the parameters (drainage, air currents, winds, temperature, etc.) so that the best location is chosen in areas that are meteorologically most favorable. Then the factories must be equipped with systems to produce clean technology with closed cycles and possibly with a re-utilization of waste materials.

One must also bear in mind the influence on the environment not only of the industrial waste (dust, SO_2, etc.) but also waste material that is flushed into the waters, and of thermic pollution.

Planning of Agricultural Development

The ecological disequilibrium of the modern world is due partially to poor utilization of the soil for industrial cultivation, to the detriment of food cultivation, which is more profitable from one point of view, but which is also subject to sudden annual fluctuations due to meteorological conditions and unforeseeable infections and infestations; in this case increasing quantities of chemical and biological means of protection are required.

This industrial cultivation also distracts the interest of the cultivator, who no longer uses the land for his basic food.

In some cases, too, inadequate or hastily established agricultural settlements (after deforestation or poor use of the land for pasture) have caused permanent changes in agricultural lands: erosion and the formation of deserts, depriving man and animals of vast inhabitable areas, which now must be found farther outside, as happened first in the Sahara and today in the Sahel.

Steps will have to be taken at the educational, socio-scientific and technical level, as is already being done by the United Nations Organizations to halt and possibly reverse the tendency to turn the land into desert.

In the move to new farm lands the developing countries should carry on research on the fertility of their soils, in order to make better use of the available land and thus avoid situations which could lead to the destruction of the organic structure of the soil which is the essential element for fertility.

This requires a considerable interdisciplinary scientific effort because of the complexity of the problem and the variety of parameters for the different conditions in the various parts of the world.

Water

A problem of primary importance in these settlements is the availability of a water supply for drinking purposes, for hygiene, for agriculture and for industry.

Many of the developing areas have a very irregular distribution of water supply during the course of the year, and therefore some areas are subject to drouth, resulting in famine in vast portions of the population. In other areas the water supply is not regulated or controlled and so becomes polluted, forms swamps, and becomes a source of disease and causes floods.

In other regions water is scarce and insufficient and limits the development of these areas.

Modern science and technology should, on the one hand, take all measures to assure complete protection of drinking water, provide for engineering works to regulate the course of rivers and lakes for industrial use and for irrigation. On the other hand, science and technology should provide means for these countries to develop research regarding the water-bearing strata of the land, or when this is not possible to introduce modern techniques for the desalinization of salt water and brackish water. Here, too, the Pontifical Academy of Science in its 1975 Study Week tried to call attention to the problem for developing countries (*).

The ecological and meteorological aspects of this problem should also be given some thought since rainfall is related to climatic conditions, and also to the type of cultivation of the land.

New trends

Alternative models other than those for the creation of huge cities can be designed by developing suburban areas. In the agri-

(*) Semaine d'Etude sur le Thème "Membranes biologiques et artificielles et la désalinisation de l'Eau" 14-19 Avril 1975, Pontificia Academia Scientiarum, Scripta Varia, 40 (1976).

cultural villages especially use should be made of all possible technological means to provide drinking water, water for irrigation and also sewer systems and wells to avoid pollution.

Steps should be taken also to improve the housing, which should preserve the local tradition but eliminate those negative aspects which make it ugly, unattractive or even dangerous. Actually it may be necessary to change the construction technique of some dwellings where science has proved that parasites and harmful insects can settle, thus creating endemic centers; for example, in the case of Chagas' disease, which is widespread in all tropical areas where the parasite carrier establishes itself in the primitive huts of mud and straw.

Moreover technology is needed which, within the limitations of the economy, will bring energy to the rural areas: that is, light and motor power, using eventually wind and solar energy.

These undertakings would make living more pleasant and could perhaps be combined with the introduction of cultural promotion, such as schools, recreation facilities, audiovisual equipment.

Agricultural methods should be improved in order to provide a better income to farm workers and more efficient health protection. Modern agronomy techniques for both genetic and cultural improvement should be provided for the rural population in order to increase the production of the land and to supply the food requirements not only for the farmers but for the entire nation.

To avoid the concentration of population and industry in the cities, it might be very important to study area by area models for the combined development of agriculture and industry, as well as handicrafts. Naturally in this case it might be advisable to take into consideration the small and medium-sized industries, in order to provide on-the-spot possibilities for earning a living without the need to travel, which is still today the greatest attraction of the city.

Examples of integrated areas of this type in Europe (Holland, Belgium and Veneto, Italy) and in the United States could help to orient new settlements in the developing countries toward global solutions, when adequate planning and the necessary funds can be made available.

NUTRITION

In the opinion of the Holy See the food problem has priority over all others. It is important for the well balanced development of community life to assure that food that is adequate in quantity and quality is available for everyone. This need is not met in all the developing nations for reasons which vary from one geographical area to another. For this it would be necessary to transfer basic knowledge and practical experience along lines other than those of a simple transfer of technology.

(1) *Conventional Foods*

The particular geographic, environmental, meteorological and climatic conditions of many developing areas require not just a simple transfer of knowledge and methodology, but a completely new study of local problems regarding the cultivation of food plants, their protection against harmful factors, selection of varieties with a high protein content, the use of fertilizers and pesticides. In the field of zootechnology, not only genetic needs should be considered but also the possibilities of producing resistant varieties of animals to provide good quality meat, which can be adapted to local climate and pastures, defending them from parasites, and preserving their health and quality.

The problem of fertilizers should not be viewed only as the transfer of a technology — that of synthetic fertilizers — which requires the building of new chemical factories in the various countries, but also as an effort to utilize more rationally all the resources and possibilities for improving the fertility of the soil, either by cultivation methods or by promoting studies on the fixation of atmospheric nitrogen and the particular microbiological conditions of the tropics.

The same is true for pesticides, which are today the only means of protecting the crops from damage, but they weigh heavily on the economy of the developing countries. In this field too we must develop other methods of control, especially biological ones, to assure the best protection.

These problems have in recent years been the subject of much

concern for the Holy See, which through the Pontifical Academy of Science has invited outstanding scientists from all over the world to discuss them at the Vatican, has produced a vast documentation, and especially has indicated new directions for their solution (*).

To the problems of nutrition are added today, even in the developing countries, problems concerning superurbanization and the great concentrations of population in the cities. These make necessary new advanced systems to provide for the preservation and transportation of large quantities of foodstuffs.

The food toxins that are produced, especially in tropical countries, by fungus contamination, such as the aflatoxins on peanuts and the ophiobolines of rice, are a cause of great concern to the whole world because of their role in the epidemiology of certain forms of tumors. All this requires new sicentific research and a study of technical processes for food preservation which must be adapted in each case to the local conditions.

Another aspect of nutrition is the fact that owing to eating habits or customs the diet is not always rational from a physiological point of view. I might mention the classic cases of the past, such as pellagra in those countries whose only basic foodstuff was corn, or more recently the use of bean varieties with insufficient fundamental amino acids.

In this case the collaboration should be extended to research for new plant varieties, and to dietary education toward other types of food; this is not an easy task and should be done by modern teaching methods, eventually by audiovisual aids and television.

Some types of diet which are not well balanced or are physiologically inadequate (improper carbohydrate/protein ratio) should be corrected by the use of food supplements which are economical and acceptable to the countries concerned.

On the subject of a better diet, particular emphasis should be given to the use of renewable biological resources, from the sea, the lakes and the rivers.

A rational use of fishing can provide an important source of

(*) Semaine d'Etude: Produits naturels et la protection des plantes, 18-23 octobre 1976, Scripta Varia, 41 (1977).

protein, but the abuse and the wrong use of methods and systems can cause destruction of some species and ecological disturbances and thus pollution of the waters.

It is very important that in the transfer of scientific data these points be kept in mind, in order to develop a new and broader form of education and also technological systems for fishing, with respect for ecological equilibrium, as well as provisions for the preservation of certain animal species, such as the creation of area for fish breeding for the replenishment of streams and the use of coastal lagoons for acquacultures.

(2) *Semiconventional Foods*

It is important to give some thought in the developing countries to supplementation of the diet of livestock by semiconventional foods, such as "fish meal" and cereals enriched with essential amino acids produced microbiologically.

The establishment of these food processing industries can make a valuable contribution toward the solution of the problem of famine and the rational use of renewable resources.

These possibilities, however, must be properly studied in order to avoid ecological disturbances and the destruction of certain species.

(3) *Non-conventional Foods*

The production of non-conventional foods has been the object of research by numerous industrialized countries. These foods consist generally of proteins from unicellular organisms such as lower fungi or yeast, or even algae. To improve the feeding of cattle, which is important for the subsistence of man, it is important to study the use of such technologies adapted to the conditions and the possibilities of the various countries. In this connection we should use not only technologies and methods which utilize materials such as hydrocarbons, but also those which make possible in the cultivation of substrate the use of agricultural byproducts which are typical of each region: cellulose materials, sugars, alcohol.

The culture of microscopic algae such as *Spirulina* also offers new sources of vegetable protein which can present an alternate solution to the problem of hunger if used as a basis for the feeding

of meat-producing animals, thus making possible great economy of cereals, which are being used more and more for the nutrition of man.

Hygiene

(a) The first step in safeguarding the health of a nation is the general hygiene measures which have already been mentioned. An important requirement is the education of specialized public hygiene personnel to provide the basis for the prevention of disease.

This broad-range activity in the health field requires at all levels the education of medical and hygiene personnel, who must become acquainted with the modern methods available. Here too the preparation and education of personnel forms part of the collaboration in the transmittal of knowledge.

The preparation of workers must be, as is done by the WHO (World Health Organization), combined with educational and cultural programs for those countries which are in a position to understand the benefits of control in this field. This capillary action by the schools should be combined with the work of sanitary hygiene operators and of members of all religious denominations.

While it is important to employ modern technologies to solve the tremendous problems of public hygiene such as reclamation of the land, warfare against endemics and epidemics, protection of the water supply and hygiene of foodstuffs, great caution must be exercised in transferring modern medical practice indiscriminately to all countries.

For the treatment and prevention of disease, medical and paramedical personnel must be trained, and schools, universities and hospitals must be established in accordance with the latest techniques. The example of certain highly successful centers such as the one at Ndola in Tanzania and at Kampala in Uganda should be followed and developed in the various regions.

At the same time, as already mentioned, because of the difficulty of access to many remote villages, we must test and prove the validity of popular or folk medicine, which in some regions is being integrated with modern scientific medicine, and we must

enlist the cooperation of those people who follow traditional methods, to meet today's needs and eventually develop new structures. Two-thirds of the world population do not enjoy the benefits of modern medicine. In order to bring about a change, it is important, especially from the cultural and economic point of view, to proceed gradually and bear in mind the importance of local traditions.

Public Health

Public Health Care - Preventive Medicine

A problem of fundamental importance for the public welfare is *medical care*, which should be provided for the largest possible number of people.

To achieve this goal, knowledge of medical science and technology must be available at all levels.

One of the first requirements is the collection of data on the individual population centers and on the diseases and their causes, as well as on the social and environmental factors that can cause them.

Another requirement is that on the basis of this information a program should be set up for the forms of intervention that would be most effective.

General hygiene and preventive medicine must be the main point of action for all countries. In this regard collaboration with the more developed countries can be based on the training of personnel specialized in public hygiene, on joint research in the biological and medical fields regarding the causes of many tropical diseases, the carriers and the "reservoirs" of parasites, malnutrition and the use foods such as vegetable proteins which should be physiologically valid. And here it is well to remember that a large part of the population of the world is underfed (*).

Preventive medicine can bring about a reduction of the occurrence and the spread of disease.

For direct medical care it is necessary to set up a model, which

(*) The Pontifical Academy of Sciences has for many years focused its interest on this point: vide Semaine d'Etude: « Use of fertilizers and its effect in increasing yield with particular attention to quality and economy », April 10-16, 1972, Scripta Varia 38 (1973).

may even be the same as that of the industrialized countries. But economic and social conditions as well as geographical and environmental factors will require a certain period before each country can conform to this model. It is therefore important to proceed gradually, step by step, finding a temporay solution in *local* medical units, which were first planned in Latin America about sixty years ago and put into operation in Venezuela. These medical units must cover a certain territory and serve a certain population and have all the essential medical structures to carry on their activities: doctors, nurses, auxiliary paramedical personnel and other indispensable infrastructures, such for instance as connections with a hospital center to which eventually the more seriously ill can be transported by plane or helicopter.

In organizing social medicine, however, care must be taken not to try to transfer to these countries the highly specialized structures which characterize modern medicine, and perhaps represent an excess of technology in the medical field.

This refers not only to the type of education for the doctors but also to the adoption of techniques and methods of care.

In setting up medical schools cooperation is indispensable among doctors, nursing and paramedical personnel oriented toward basic medicine, who should stress and study thoroughly the particular aspects of diseases which because of the climate are prevalent in the tropical regions, such as malaria, trypanosomiasis, leishamniosis, leprosy, etc.

Medical care can be provided not only at the level of local health units but also at the level of the agricultural community or the village; but it should always be organized around a central hospital facility to which the outlying services can refer whenever necessary.

Mental disease, which is particularly prevalent in large urban concentrations, is due in many cases to biochemical changes of various origin in the central nervous system, or it can be caused by stress, or inadequate conditioning especially among young people.

Poor family environment, family quarrels, overcrowded living conditions and uncertainty as to the future, so common in urban and suburban areas which lack the services and advantages of the city and direct contact with nature, which has been carelessly neg-

lected, can cause and be the basis of mental disease, which is today rapidly increasing with the growth of cities.

The developed countries must do their share in attaining health, and action must he taken toward a true social rehabilitation rather than a salvaging action, which is often too late and of little help.

For this, basic research in neurology is required, as well as research on behavior and aggressiveness.

In this way it will be possible to provide health care for even a very large territory.

New methods and new techniques will be required to deal successfully with health problems in overpopulated areas, such as India and China.

Refined techniques will have to be used to bring the benefits of modern medicine to the poorer nations without creating social or economic disequilibrium, and especially to establish, even if not in ideal conditions, a satisfactory relationship between the number of doctors and that of patients.

Vaccinations, a typical instrument of preventive medicine, must be feasible even when there are very large numbers of people to be treated. For example, in vaccination, when choosing between two methods — one based on injection and the other oral — the latter is naturally easier unless one uses sophisticated modern techniques which might be possible for example in highly populated urban areas.

Traditional Medicine

In discussing medical organization in the developing countries we must not overlook the important function of traditional medicine, which still today is helping many millions of people.

For a number of psychological reasons and also to provide medical care in very remote places, modern science must make use of traditional medicine and combine it to best advantage with modern medicine, seeking a constructive cooperation between modern and traditional methods.

The example of a large Asiatic country, China, is extremely interesting; the same happens in India with ayurvedic medicine.

Also in Latin America some forms of traditional medicine are blending the popular element with the modern.

We must bear in mind that traditional medicine today still serves 75% of the world population.

It is important that scientific collaboration in this regard be established to ascertain the efficacy of certain therapies and certain medications used in folk medicine. In this way it will be possible to fill in the gaps with modern pharmaceuticals. However, until an adequate effective health organization can be set up, we cannot overlook the importance today of health practicioners and healers in some communities who combine empirical knowledge regarding the treatment of disease with a certain undeniable ability to inspire confidence in the patient.

Research in this field can benefit industrialized countries because in traditional medicine one can find important cues not only for the treatment of mental illness (we recall the group therapy adopted by the shamans of Indian tribes), but also to discover active principles in plants and in animals, as for example "Reserpine" in *Rauwolfia* which has brought great benefits in the case of hypertension and as a psychopharmaceutical.

These systems of traditional medicine have also the advantage of being able to reach remote areas which are almost inaccessible.

The rapid and indiscriminate introduction of modern medicine in all the developing countries can be achieved only very slowly, if we think of the vast areas which are to be served. There would have to be available a large number of people engaged in health services in every country, and this takes years to prepare and involves great expense for the importation of medical instruments and supplies.

Even if the present tendency of the health policy of the WHO is to reduce the number of essential medicines, yet their importation for those countries would be a great economic burden.

The production of pharmaceuticals in the developing countries should be encouraged and helped, even if only of those medicines which are today regarded as essential by the WHO, but also the valid resources of traditional medicine must not be overlooked.

In this case further research is necessary, and it can be done in the developing countries.

Medicines can be produced in the developing countries only when the economic conditions provide a large enough market to justify this, a thing which is not always possible today when there is increasing fractionization among the various nations.

Some large developing countries which already have industries for the production of pharmaceuticals could help by integrating other developing countries into their geographical area.

But these are long-term measures and for the present cannot eliminate the necessity to import many essential drugs. Furthermore, for the preservation of human dignity it is important to assure that new drugs under study in the industrialized countries should not be indiscriminately tested on people in the developing countries, where there is a lack of legislative protection in this field.

Instead there should be joint collaboration in the study of those pharmaceuticals used to combat typical diseases of the developing countries, particularly of tropical countries, for otherwise it would not be possible, in the interest of the people of those countries, to carry out these experiments elsewhere because of lack of clinical cases.

SCIENCE POLICY

1. *Science and Politics*

It is now universally accepted that science should be considered a creative and active force in the world. On this basis, we can no longer be indifferent and must aim for a critical science which does not limit itself to merely reflecting the world as it appears to the various ideologies, but contributes to modifying it and placing knowledge at the service of the general good of mankind.

The profound meaning of science becomes thus the discriminating use of knowledge for the development of humanity. Therefore it is obvious that research must be free from all conditioning by political power.

Science detached from society and from social struggle, dedicated only to the problems of research, it seems would guarantee not only its own development but also its independence from political power and from private interests, leaving to governments the task of applying the scientific results. In reality, experience has shown that political power tends to utilize science and its results for the maintenance of its own position and for its own ends, so that scientists find themselves unwillingly involved in the contest.

The responsibilities of science to society are much greater than the scientist without critical principles can or wishes to admit. Science in fact does not limit itself to giving advice: in reality it participates with its men in the transformation of society by providing a general framework, indicating the variables to be dealt with in anticipating changes and preparing strategies to overcome obstacles.

Until now, except for some rare exceptions, we have limited ourselves to a statement of the social and political responsibility of scientific research, without facing the problems deeply rooted in the relationship between scientific work, cultural change, social change

and political struggle, which prove in reality to be the problems of values and of needs. The researcher cannot separate himself from his civic duty as a citizen of making independent decisions regarding the destiny of man and of society, because insomuch as science contributes to the critical formation of free decisions regarding the destiny of man and of society, to the abolition of power structures, to the strengthening of democracy, his activity is political. That implies, basically that science must not identify itself with any established order or with any ideology.

In other words, science must defend its own right to resist the establishment, since the latter uses the results of research for its own benefit and not for the benefit of society.

History and recent world events show that establishment uses science to its own advantage and for control of the socio-political system, thus becoming an instrument to impose approval and to promote private interests.

Faced with such a situation, to continue to uphold the separation between science and politics becomes for the scientific community a failure in its duty, for it nullifies the very possibility for science to teach and inform. So it becomes necessary to develop a science which criticizes and participates in order to avoid the misuse of its findings. A more critical science must reflect on itself, on its transformations and its own methods of development, in an epistemological self-analysis which will point up the models of reference adopted on a purely scientific level.

A science that participates, that is rooted in social action and social change, not only cannot overlook the political implications of its findings but also must modify its structures in order to improve its contribution to society.

2. *Evolution of the Concept of Science Policy*

The term scientific research is commonly used to mean the ensemble of activities which aim at the discovery and utilization of scientific knowledge. This includes:

basic research, which is the systematic study of nature and

of nature's laws purely for the purpose of knowledge, and has nothing to do with its immediate practical applications;

applied research, whose aim is to discover and experiment with the possible practical applications of the results obtained;

development, which concerns the production on an industrial scale of technological innovations.

The Anglo-Saxon symbol R and D (Research and Development) is today used internationally to indicate all three of these activities. However, they can be regarded as separate only in principle, for in daily practice it is not rare that research and application tend to overlap.

Of more recent origin, and related to the fact of public intervention in the scientific field is the term *oriented research*, to indicate study oriented toward certain definite priorities, established in another sector, which still are not immediately related to practical ends.

Many scientists agree that one of the characteristics of the history of the 20th century is precisely the constant shortening of the interval between a scientific discovery and its practical application to everyday life. More than a century elapsed between the discovery of the principles of photography and its development on an industrial scale; for the telephone fifty-six years were sufficient; for radio thirty-five, for television fourteen, and five for the transistor.

Such a phenomenon, which was due to a favorable historic and social context, was largely determined by the structural characteristics of the industrial system.

Governments, however, tend not to intervene directly in the organization of this field. In the scientific field, as in the economic field, it is generally believed that the greatest productivity can be attained only in a free market system. The State leaves the promotion and orientation of research to private enterprise and limits itself to the regulation of formal legal relations through legislative provisions such, for example, as the first international agreement for the control of patents, made in Paris in 1883. Subsequently, however, as the results of scientific and technological progress are seen in all branches of national life and its promotion requires ever-increasing investment of human and economic resources and for

longer terms, it becomes inevitable that governments intervene always more directly and extensively.

Historically we can distinguish two periods in the attitude toward science: *back in the fifties*, scientific research was considered an exogenous factor with regard to economic policy; even if the role of *scientific knowledge* in economic development has been known ever since the industrial revolution of the last century, still it was *considered an independent process which the political class regarded as being outside its sphere of action and influence.* With the passage of time, however, the growing importance of new products and processes in economic progress and the rise of industrial sectors based entirely on science, such as the electronic and nuclear industries, have led to a profound change in the attitude of responsible groups both public and private, toward research: *in all industrialized countries there is now a growing concern as to* what the duty and the role of the State should be in scientific research.

The concept of a policy "for science" which until then prevailed thus gradually became integrated with and partially replaced by the concept of "science for politics".

Contemporaneously with the growing preoccupation with the negative effects of technology on the natural environment and on society, the *social need for scientific research was moving toward* more concrete and more immediate objectives: together with the concept of "living standard" there appear ever more insistently the concepts of "social security" and "quality of life"; that is, science and technology can contribute not only in providing security and well being but also in furnishing solutions for harmful technological "fall-out".

This evolution in the concept of scientific policy causes crisis in the individual countries, which are obliged to re-examine thoroughly their policies of scientific research. The need to find a solution obliges the responsible groups in each nation to abandon gradually the policy of vast long-term programs in favor of more immediate interventions, which can realize more "concrete" choices on the one hand, and on the other more "universal" choices, such as health, urban development, transportation, work security, telecommunications, etc.

These new choices postulate by definition a diversification of effort and a new division of labor, the creation of scientific services

of broad dimensions, and especially cooperation among nations, all of which are equally involved, through programs and methods which are *completely new.*

Undoubtedly the shock has been very great, so that even today there appears in various sectors of public opinion a climate of diffidence and skepticism regarding research.

How has it been possible to arrive at such a change of attitude? What mechanism has broken down, what has happened?

"A series of episodes which have occurred in the last twenty years have shed light on the crisis in the relationship between man and his environment and the need for a radical change.

"Public opinion has been deeply shaken, among other things, by the repeated experiments in nuclear explosions and the fear of resulting cancerogenous effects; by the London smog which in 1952 killed more than 4000 persons; the growing use of pesticides and herbicides with the possible effects on the complex system of vegetable life and the thin layer of organic earth so important in agricultural countries; the spread of DDT throughout the entire biosphere, through the alimentary chain (in the fat of penguins and seals in the Arctic, in animal organisms of Barbados, of India, in the mothers' milk, in marine plankton, etc.); the biological involution of rivers and lakes (Orta, Erie, etc.), and the degradation of other lakes; the extermination of whales, the events of the Rhine River.

"The accusations against technology thus create an attitude of rejection toward science and technology, which are associated with nuclear arms, biological and chemical weapons of all sorts, pollution, deterioration of the environment" (V. CAGLIOTI, *Uomo e ambiente oggi*, Acts of the National Academy of the Lincei, Rome, 1972).

In this connection we can distinguish four main questions to which the studies on scientific and technological research policy are seeking a solution:

(i) how to determine the "ideal" quota of social and economic resources which in given historic-economic conditions any country should invest in R and D in order to reap the maximum benefit from research and development activities carried on inside the country itself or outside the country;

(ii) in view of the limited available resources, what criteria

are to be used in choosing to carry out *certain programs* of research and development, rather than others;

(iii) how to anticipate and control technological development, so as to *avoid its negative social effects* without interfering with its continuous evolution;

(iv) how to create over the long term *the most favorable social conditions for realizing pre-established scientific programs.* There are factors such as the *preparation of specialized personnel or the construction of plants* which involve long-term commitments and which, once undertaken, often prove to be irreversible.

3. *Organs of Science Policy*

Above all, we must not forget that true development, development which has real human value, is the result of a systematic global process, that must take place with strict respect for a collective sentiment which is difficult to define, but which orients and promotes the passage from the past — of which certain fundamental aspects must be preserved — to the future which it is intended to build. An effective science policy is made possible by a harmonious relationship between science and public opinion.

It seems that the process of communication, even if we wish to regard it as a pre-scientific stage, should include the principle of participation; and in this the translation of specialized language into everyday language and the equally important translation of urgent social needs into scientific terms is essential.

Participation — together with communication which it presupposes — implies a continuous cooperation between science, politics and the general or popular will in a system of information which is complex but can be easily anticipated and realized, which goes far beyond the legally established norms to find its source directly in democratic ethics.

The science policy of a country must be the result of a dialogue and agreement, in which the governing forces, scientists, technicians and the legitimate representatives of the various classes of consumers must participate. Without this participation the

benefits of a science policy can be dispersed or completely lost. Such collaboration must guide the general orientation of science policy and applies also to certain very important problems such as the analysis of the risks and benefits involved in the spread of reactors, the destruction of forests, industrial pollution, etc.

As the results of scientific and technological progress are felt in all sectors of a nation's life and as its progress demands the investment of human and economic resources on a larger and larger scale and for longer and longer terms, it is inevitable that government intervene always more directly and more extensively.

During the thirties the more advanced industrial countries created *National Research Councils*, whose main functions were the administrative coordination and support of basic research in the universities. The Research Councils have already given positive results in various ways, while certain experiments in the formation of ministries of a bureaucratic nature have been less satisfactory.

As *participants* in government institutions we find the Academies and Societies for the Advancement of Science. The first should give advice to the governments, accomplish certain more or less specific tasks, and also develop within their framework institutes of basic and applied research. Being by nature limited organizations, the Academies cannot take the place of the *Societies for the Advancement of Science*, which are multi-disciplinary and, combining the scientific community with the civic community of each nation, they represent the best form for the free expression of the various currents of modern thought in science and technology and are the best place for realizing the scientific and technological aspirations of a country; they represent, from every point of view, a means for the enrichment of society. Every government should encourage their formation and their development.

The organisms of scientific policy have a primary duty to fulfill in the developing countries: that of deciding the proper equilibrium between basic research and applied research. Indirectly they can orient research toward certain national problems. An example of this indirect action, which should not obstruct the creative activity of scientists, is the organization of integrated programs in which specialists in the various disciplines participate in order to find a solution for a specific problem of national importance.

Moreover, thought must be given to the creation of regional organisms for scientific planning and to their expansion. Although this undertaking is conditioned by the political situation, still certain questions, such as construction for the best utilization of river networks, the use of secondary natural resources, the preparation of qualified personnel, the dissemination of technological and scientific information, are regional problems that can be effectively handled through the collaboration of several countries.

Another activity of the Research Councils could be the development of so-called "High Level Research Centers", which would be composed of a certain number of research units. These centers should at the same time be used for advanced scientific education, for the adoption of the most appropriate techniques for the scientific needs of the nation, as well to encourage scientific exchange with the more developed countries. These centers can be regional in nature or even continental. The *Center for the Study of Physiology of Insects and of Ecology* (I.C.I.P.E.) in Nairobi, created through the initiative of the Academies of Science of Europe and North America, the Nutrition Institute of Central America and Panama (I.N.C.A.P.) with headquarters in Guatemala and the Latin American Center for Educational Technology in Rio de Janeiro, both under the auspices of the Pan-American Health Organization, as well as the Centre Européen Recherche Nucléaire (C.E.R.N.) or the European Institute of Molecular Biology (E.M.B.O.), are good examples of scientific cooperation that is regional in character and organization and helpful to the developing countries.

In setting up a good scientific and technological policy, particular attention should be given to the organization of intermediary units, that is, of technicians, because the function of the technician is extremely important. On-the-job training is essential but it should not overlook the importance of a basic cultural education in order to enrich the personality of the technicians.

Finally, two problems present themselves: first of all, that of the salaries of the Research Institutes, which are lower than those of industrial workers; then, the "status" of the technician should be improved and the difference in social scale lessened, for these lead to the creation of unions, which, if too aggressive, can be harmful to the progress of the Institutes.

4. *International Collaboration*

A disturbing fact that results from a study of international relationships is the enormous technological difference which separates the industrialized countries from the developing countries and, in the western world, the United States from the European nations. This is a subject which has attracted the attention of political and scientific men especially since 1965. At that time it was learned that the United States spends for research and development three and a half times more than all of western Europe.

The gap referred not only to the technological sector of development but also to the scientific sector of basic research. The reasons for this went back to the period preceding the Second World War and can be attributed to such factors as: the inadequacy of university structures for the needs of modern research and the growing student population, the long delays in administrative-bureaucratic procedures, the centralization and lack of flexibility of scientific institutions in modernizing themselves, the isolation of the universities and of the academic world from the needs of industry and of society in general.

The events of recent years, such as the growing economic depression and the energy crisis, have again called attention to this problem with all its urgent implications. At a time when the importance of close interdependence among all the countries of the world becomes more evident, the profound discrepancy between the rich, industrialized countries and the poor, developing countries becomes more apparent and distressingly urgent.

It is therefore obvious that international cooperation is a necessary condition not only for scientific and technological progress but also for the preservation of peace. Joint efforts between nations are indispensable for the close relationship between scientific research and economic progress as well as for the development of new disciplines such as those regarding nuclear energy, radioastronomy, etc., which require ever greater organizational and financial dimensions, in fact, there has heen mention of a mega-science.

It is in this framework of a world policy for the development of science and technology, with particular regard to the poorer nations, that the comments and suggestions contained in this report on science and technology and the developing countries are to be viewed.