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PREPARATIONS FOR THE UNITED NATIONS CONFERENCE ON SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

Science and technology and the future: a systematic review of the main points of the experts' report on item 7 of the provisional agenda of the United Nations Conference on Science and Technology for Development

Note by the Secretary-General of the Conference

1. At its second session the Preparatory Committee decided 1/ that the documentation for its fourth session should include, in relation to item 4 (now 7) of the provisional agenda for the Conference, a progress report on the work of the experts on "Science and technology and the future" and an outline of a report to be submitted to the Conference. The progress report of the Secretary-General of the Conference on preparations for the Conference submitted to the Preparatory Committee at its fourth session (A/CONF.81/PC/29) included a section describing the structure of the report and the progress made in its preparation.

2. The annex to the present document contains an extended outline of the experts' report.

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* A/CONF.81/PC/37

1/ Official Records of the General Assembly, Thirty-third Session, Supplement No. 43 (A/33/43), annex II, decision 4 (II), sect. III.4.

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ANNEX

Science and technology and the future

A systematic review of the main points of the experts' report*

Part I. Needs and possibilities of guiding the development of science and technology for human benefit: historical and conceptual considerations

1. There are two great myths about science and technology that are, and must be, challenged today. One is that science and technology are value-free endeavours for the research and exploitation of objective reality; the other, that the fruits of science and technology necessarily benefit all mankind.

2. In reality science and technology are not free of values nor do they necessarily confer benefits on all people and societies. They are human and social endeavours, even if rigorous and methodical ones. As such, science and technology are laden with values, both external and internal. External values come from society at large and affect science by creating demands, conferring degrees of prestige, providing educational and research opportunities, and channelling funds for scientific activities. Values internal to science reside in the world views, patterns, interests, and predisposition of scientists and scientific communities as propagated through their institutions, journals, text-books, conferences, and training and educational practices.

3. Whereas the values internal to science have been exhaustively investigated in the last few decades by scientists as well as by philosophers and sociologists of science, the external or societal values that impinge upon science have not been considered determinant in the evolution of science and have thus received relatively little attention. It is only in recent years that these factors have occupied the minds of people who have become increasingly concerned with the doubtful benefits derived from the dominant direction of current scientific research. Even here, it has been more usual to blame technology and to uphold the freedom, neutrality and autonomy of "pure" science, as if it were an autonomous realm in itself.

4. When assessing the future of humanity, and the role of science and technology in assuring that it is fit for people, and for all the people, it is necessary to look at them in a global and holistic perspective. What does science do for humanity? How does it fit into the array of human activities, cognitive and other? What could it do in the future that it does not do properly at present?

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* Prepared for the Secretary-General of the Conference by Ervin Laszlo (UNITAR) on the basis of studies by a Group of Experts concerning item 7 of the provisional agenda for the United Nations Conference on Science and Technology for Development (Science and technology and the future).

5. In the light of questions such as these, science and technology must be taken as integral elements of the growth and development of human societies. Science and technology are guided - at least in part - by societal values and practices, and they in turn have an effect on social and economic growth and development and on cultural diversity. But it is one thing to note that science and technology, while bringing material benefits to some societies and to some groups and classes within societies, bring inequality, harsh environments and frustration to others; it is another to conclude that science is incapable, by its very nature, of altering and improving the effects it produces. The role of science and technology could be very different in the future from what it is at present. In order to actualize the positive potentials of these crucial dimensions of human activity, one must not hesitate to look at the large picture and at the total picture, and to ask how science and technology can best be turned to human benefit. This then, is the challenge before us.

6. What we regard today as "science" is not synonymous with all that science has been or can be in the future. It is a historical and cultural phase, manifesting the influence above all of the great successes of nineteenth century physical science and of the industrial spin-offs it has produced through modern technology. It is a mode of thought centred on the inert world of matter. It promises to explain and unify all that belongs to the sphere of material reality, while it leaves untouched many things that are specifically human. The social and moral crisis of today, which results in part from the short-sighted application of the dominant trend in science, looks in vain to contemporary science for resolution. Because of the very changes wrought in societies by the technological applications and background values of today's science, more traditional answers also appear inadequate. Only a further creative evolution of science can respond positively to the problems created by human decision-making, by making science relevant to the problems that beset the human community.

7. The "logic" of modern science is not a safeguard of truth and progress. It has become an element in the burgeoning "crisis of civilization", and is one of the causes of the moral disarray of the times.

8. Although technologies spawned by scientific discoveries, especially in the area of armaments and weapon delivery systems, are not in themselves responsible for human misfortunes, they have nevertheless created the means whereby a concentrated group of decision centres exercise a major influence on the fate of humanity. Science and technology have been made to serve the interests of entrepreneurs, dominant classes and élites, of major corporations and Governments. They offer States and élites various applications, many of which are intellectually sterile and economically burdensome, and they also create and promote polarized social systems that leave the greater part of the world's peoples untouched by their potential benefits.

9. The manifest ill-effects of science are beginning to erode scientific progress itself. Such progress was due, at least until mid-century, to a conjunction of mathematics with physical theory based on a reduction of phenomena to the molecular, atomic or subatomic level. Even the advent of quantum theory in the domain of microphysics did not change the over-all orientation of "hard"

science towards an explanation of events by reduction to causes and effects among physical units. The technological spin-offs of such an orientation centred on the exploitation of natural resources and energy for short-term human ends. Material goods and benefits could be produced, and these appeared to accord with the "scientific" mentality of our age. The resulting disregard for the management of balances and conditions of self-renewal in the domains of living nature, and even for the exploitation of non-renewable natural resources, left humanity with disequilibria and problems of one-sided development. Although contemporary science evolved many elements of knowledge that could be drawn upon to correct such problems and imbalances - modern medicine, information and educational theories and technologies - these are improperly assessed and relatively underdeveloped because of the concentration of science on material nature.

10. Because of the one-way flow of technology, even societies that had not evolved the scientific mode of thinking and acting suffer from its consequences. A new international economic (and scientific, technologic, sociologic and political) order can be established only if developing countries participate in the creation of a new orientation in science and technology, shifting the focus of concentration from a preoccupation with the manipulation of inert matter to concern with the maintenance and enhancement of the balances and processes typical of the sphere of the living.

11. The next evolution of science could and should alter the relationship between the physical and the life sciences. Rather than considering the living world as a special case of the physical world, it could consider the physical world as a special case - a foundation - for the world of the living. Such development is justified by the change in world view that is already in the making in some scientific communities. While the dominant view is still that of the universe as a complex mechanism resolvable to its elementary parts, the new view is that it is more like an evolving organism that brings forth novelty at each new level of organization and existence. In the former case it is logical to study the parts, for they alone give a clear explanation of the functioning of the whole; in the latter, however, it is logical to study the whole; for it alone manifests the structures and processes that came to be in the world in the course of evolution. The paradigm case for one is cause A producing effect B; for the other it is a network of causes and effects acting together within a structure that maintains and regenerates itself.

12. The logic of organic or "systemic" science is already emerging, and it is already using an impressive array of mathematical and related techniques. But the priorities of society are as yet linked predominantly to the older mechanistic conception and the benefits that engineering approaches can derive from it. Social decision-making, in the economic, cultural as well as the political spheres needs new priorities, oriented towards the maintenance of equilibria and the enhancement of processes of development, and these priorities could be better satisfied by sciences that are holistic yet rigorous, than by sciences that sacrifice the whole to rigour in the definition of the part.

13. In the new orientation highest priorities attach to the conservation and enhancement of the biomass, to human social and cultural experience, and to the natural resources required for human life in order that imbalances and polarizations resulting from the short-sighted application of the current scientific paradigm may be first mitigated, and ultimately overcome.

14. Humanity must cease overestimating today's technologies based on yesterday's science. It must create social and political conditions for the emergence and utilization of a new development in science. This calls for the training of scientists capable of undertaking the pertinent research tasks, and for the purposive development of social structures that can make good use of the findings. The time for achieving this is short. It is important to be clear that the main task is not to explore what humanity can expect of the science that is of the past, but what it can do to promote a science that is appropriate for the future. This is especially true for the developing countries that did not participate in the creation of the dominant scientific paradigm but could have a major role in creating the new transformation in science. Their problems must not be considered separately from an assessment of the potentials of this development for coping with them.

15. Modern science, with its heavy emphasis on physics and related "hard" sciences, is highly capital-intensive in laboratory research and empirical testing. While a few theoretical geniuses, like Einstein, could jot their first draft equations on the backs of enevelopes or on simple blackboards, the physical sciences have not had major conceptual innovations in about forty years and the testing and development of the existing theories require a high level of training and funding. Only major, well-endowed research centres remain at the front edge of scientific innovation. Given the current orientation of science, young and relatively poorly endowed research facilities, even if staffed by first-rate minds and possessing innovative ideas, cannot compete successfully.

16. Under these conditions the end-use priorities of the public and the private sectors of society strongly affect the conduct of scientific research, and therewith the development of its main conceptual core. Funding is a major element in "big science" and in all related fields. It is not accidental, therefore, that science has become what it is today: it has evolved in a materialistic, profit- and power-oriented social and economic milieu.

17. There is a definite connexion between the amount of funds allocated to research and the quality and quantity of the facts and theories that emerge. This was further believed to issue in an increase in social well-being resulting from the availability of new technologies. While the second half of the assumed loop connecting science with social well-being is contested today, the first half remains true beyond doubt. Funding for research and development attracts scientists to the favoured fields and makes for more intense activity there.

18. Notwithstanding protestations of détente, and negotiations on strategic arms limitations and disarmament, State funding allocated to defence-related fields continues to increase. a/

19. As a result of massive investment, some 400,000 physical scientists and engineers, more than half of the world's total, are currently engaged on projects with military applications. These are not simple technological applications of existing science but go deeply into fundamental research in high energy physics, communication and information theory, cybernetics and computer science, artificial intelligence and automata theory, as well as in their logics and mathematics. Science as a whole feels the effect of societal priorities. These are essentially State priorities, since in most developed countries the greater part even of fundamental research is funded by Governments.

20. Public funding of research and development in the defence-nuclear-space science sector is massive and concentrated on precise objectives embracing both a given technological task and the creation of a market for it. Social objectives play a small role in research and development, especially in the private sector where objectives without markets are seldom taken seriously. Governments provide the wherewithal for most of the scientists engaged in research and development, followed by industry with an eye to new markets. The "scientific revolution" that has taken place in the years following the Second World War has been largely funded and oriented by the priorities of a handful of developed countries: these assumed the risks and the costs, and have generated the markets that were later able partially to absorb its products and generate further funds for its research and development.

21. Change in science policy is required to change the orientation of science and technology. Such change calls for a new political philosophy. First, a rationale for choices in science and technology must be evolved. This must take into account current use and future needs, natural and social environment, and ethical and human considerations. If choices are left to the intuition of scientists, they - with a few distinguished exceptions - tend to make them in the light of the dominant values of their professional communities. Certain fields and types of research gain prestige by virtue of new breakthroughs having occurred, or showing promise of occurring in the future. These factors are connected with levels of funding that make intensive research activity possible, preparing for the breakthroughs and making the field attractive for scientists. The external factors guiding science must be rationalized. The objectivity of research on given fields can and must be safeguarded, while rational choices need to be made concerning the fields selected for intensive development.

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a/ 95% of all R and D in the world takes place in developed countries. In these countries the largest item in R and D funding is the complex made up of defence, nuclear energy and space sciences. For example, Sweden provided State funds for R and D in these fields up to 57.5% of the total invested; the United States of America 57.5% of public funds; France 53.5%; the United Kingdom of Great Britain and Northern Ireland 51.2%; and the Federal Republic of Germany 51.3%. In the last twenty years expenditures for military research have grown by a factor of 35 in the United Kingdom and a factor of 56 in the United States.

22. Since society as a whole is affected by the development of science and technology, a well-informed and critical public debate must be stimulated to determine rational choices for science policy. As this calls for more public information on science and its effects on the part of the masses than is currently available, a segment of the scientific community would need to assume the responsibility for providing it. "Science critics" would explain to people new developments in science and technology, and their social impact in the short and the long term. Unless such steps are taken, contemporary science and technology are likely to persist in their present orientation in response to heavy investments in fields that serve the immediate economic and political interests of those who control the budget.

23. The general human interest, which is the day-to-day interest of the underprivileged and powerless in the world community, and the coming interest of future generations, is the ethical responsibility of today's privileged and powerful groups. If science is to become a tool for serving the general and long-term interest of all people, the moral sense of those who control its development must be revitalized. Rather than taking refuge in protestations of the freedom and autonomy of science, they must recognize that it is a human activity, connected through multiple strands of logic and method, as well as of self-interest and professional value judgements to other, extra-scientific activities. This recognition takes nothing away from the status of science as the most rigorously controlled of human activities in the search for exact and empirical knowledge. It merely exposes a current myth that remained unchallenged as long as science produced concepts and theories which produced benefit in application to human affairs, but which is now coming to be challenged in view of the manifest ill-effects that result, directly or indirectly, from the type of research undertaken by the greater number in the contemporary scientific community.

24. In but a century and a half mankind amassed sufficient knowledge to make it possible to satisfy all human and social needs and requirements, as well as to destroy all human beings and their vital habitat. It is a sad commentary on the development of science and technology in recent years that the likelihood of universal self-destruction is now higher than that of a universal and long-term satisfaction of individual and collective requirements and needs.

25. Science, however, unlike secular or sacred dogmas, remains open to the possibility of its own self-transformation. Such transformation could well occur in the remaining decades of this century, provided that the international community recognizes the limitations and dangers of current science and technology, as well as the possibility of purposively guiding its evolution. In the area of science and technology, no less than in other areas of the new international economic order, the crucial factors are the mobilization, concentration, and rational exercise of national and international political will.

Part II <u>The misuses and ill effects of contemporary science and technology: analyses of present-day conditions and their causes</u>

26. The intrinsic orientation of scientific research is coupled with a large-scale exploitation of its findings and theories, and their transfer to almost all parts of the world. In the process, several problems arise. Some are connected with the nature and orientation of science itself, in view of the types of technological applications it inspires and produces. Others are connected with the mechanisms and priorities of the transfer of science and technology. Concepts and applications may have been beneficial when they arose in specific historical and social contexts in the countries of their origins, while the same concepts and applications may prove to be pernicious when transferred elsewhere, to countries passing through different phases and forms of economic and social development. Consequently, some effects of contemporary science - such as weapons of destruction - are inappropriate on all counts while others are inappropriate in particular places and in specific circumstances, such as agribusiness and capital-intensive industry.

27. The partial or total inappropriateness of several of the technologies deriving from contemporary scientific research was due, until recently, to the indiscriminate manner in which the fruits of scientific research were exploited. "Anything that can be done, must be done" became known as the "technological imperative". The magic powers of science in the eyes of technocrats and many Governments made for recourse to "technological fixes" wherever problems arose, often to the neglect of the problem itself. (A California slogan put this aptly: "Technology is the answer. But what was the question?") The result was the emergence in industrial societies of technocratic classes and technology-dominated values. Technical innovations were called upon to solve societal problems, and people were conditioned to expect and accept such solutions. As further problems arose - often in the very application of technical solutions - further innovations were called for, and so on, in a self-reinforcing causal loop. In the process, profit and power entered into play, leading to a selective elimination of diversity in favour of mass solutions benefiting from economies of scale and centralization of control.

28. However, in the 1970s a new phase in society's relations to science and technology has emerged. Owing to the pressure of the accumulated problems (caused in part by the short-sighted application of previous technical solutions), the public has passed from a phase of simple admiration and amazement vis-à-vis science and technology to a phase of demystification and doubt. Dangers associated with the indiscriminate use of technology were being more widely recognized, in military as well as civilian fields. "Technology assessment" was born. This reversed the previous conception, according to which if a process was scientifically understood and technically feasible, the only remaining questions had to do with the ability of the market to create a demand for it. Lately, the decisions of Governments

have entered strongly into play. By the early 1970s both the United States of America and the Union of Soviet Socialist Republics decided to suspend the development of anti-ballistic missile systems. More recent decisions in the United States not to build the B-1 bomber, and to abstain from building a supersonic transport plane were cases in point. In the last few years an entire array of socially determined limits have been set to technical developments in the form of air and water quality standards, reservation of wilderness zones, protection of coastal areas, urban planning and zoning, as well as legislation for measures to prevent soil erosion, destruction of wildlife, overcropping of farmland, overcutting of forests, and overfishing of lakes and oceans.

29. But technology assessment alone does not change the basic orientation of contemporary science; it only makes for more selectivity in application of its spin-offs and consequences. In its current socio-economic and political setting, science and technology still produce inequalities by concentrating on fields and on regions where funds for R and D and capital for technological applications are available, that is, on the world's rich rather than its poor. Science and technology also tend to exacerbate social problems through creating capital and skill-intensive types of employment - again, favouring the rich at the expense of the poor. Moreover, technology is still ready to turn to the production of wasteful and socially and humanly useless products and services, catering to the needs of the affluent and the powerful. On balance, the social impact of science and technology tends to be negative: it widens socio-economic gaps, endangers the environment, and produces artificial unemployment. Science and technology also inculcate artificial expectations and demands, which encourage conspicuous consumption and waste on the part of the rich and the powerful, and create frustration for the poor and the powerless.

30. Perhaps the paradigm case of the misuse of science and technology with respect to society and human welfare is that of military research and weapons technology. It is a misconception to think of military and weapons research as merely technological. Today, such research is oriented more than ever towards qualitative refinements that call for basic research. But because of secrecy, whatever positive spin-offs it may produce are unequally available and are in any case incommensurate with the level of funding and brain power invested in it. It inspires the creation and perfecting of military complexes which, both by their size and by their purposes, are counter-productive for all societies, developed as well as developing. They waste energy and resources, provide relatively small-scale employment owing to their capital and skill-intensity, and represent an excessive financial burden for national economies.[12/] It also cannot be said that military research assures national security. In a world where peace is kept primarily by the mounting "balance of terror" conveyed by strategies of deterrence and the spectre of mutual annihilation, qualitative breakthroughs in weapons technology by any side could quickly disrupt today's

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12/ It is known that 40 per cent of all financial resources devoted to R and D have been used for military purposes, where investment still outstrips all civilian R and D, being of the order of $30 billion annually compared with $20 billion for peaceful uses.

unstable equilibrium. On the regional level, unequal access to arms could encourage the use of a temporary military superiority to settle new and old conflicts. Finally, the balance-sheet remains negative even on the score of productivity: in the military area research input per unit of output is at least twelve times greater than in civilian fields.

31. Science and technology are dominated by the short-term interests of small economically powerful groups not only in regard to the type of research and development that is undertaken and the kind of technology that emerges, but also with respect to the transfer of the existing body of science and technology. The transfer of science and technology leads neither to a universal access to their achievements nor to the blocking of development, but rather to truncated development created by inegalities on the international level. The transfer of technology responds to laws of the market and the decisions of centralized power groups, not the real needs of people and societies. In general, a technology is transferred when its transfer corresponds to (a) a demand by the recipient (to manufacture a new product, to improve productive capacity, or to substitute for some import), and (b) to the perceived interest of the exporter (to enlarge a market, to protect itself from a competitor, or to realize high and short-term returns on investment). In transfers encouraged or executed by States, immediate national interests play the major role, in the economic as well as in the political and military fields. The perceived interests of exporters and importers seldom coincide. Consequently, technology transfers are more favourable to the one or to the other, depending on their bargaining power.

32. Technology transfer from the developed market economies is guided by a search for profit under the laws of competition. Current statistics show that transfer is concentrated in sectors and regions where the rate of profit (or return on investment) is the highest and where it serves the purposes of defensive or offensive competition: to prolong the use of a product or technique (or prevent encroachment by competing ones), or to create a new market, enlarge the market share, launch new products, or appropriate new reserves of low-cost labour.

33. The logic of technology transfer is internal to the productive systems and external to the purposes and needs of the users. This logic constitutes a constraint which those directly involved in technology transfer cannot normally overcome.

34. Technology transfer is also constrained by the inequitable penetration of information in developing countries. Information in all its forms - as science, technology, value systems and modes of social organization - reaches typically only the modernized sectors of third world countries. This contributes to a marked duality in patterns of development, in levels of skills and education, and in social and economic status. But even to the modernized sector, not all forms of information and not all technologies have penetrated. A series of selective filters are interposed between global scientific knowledge and the kinds of technologies actually transferred to the third world. Economic and political considerations intervene, the most important of these being profit and market-maximizing strategies. The technologies that ultimately become the object of transfers are often poorly adapted to conditions in recipient countries, having been evolved under different socio-economic conditions, for different purposes.

35. The appropriateness of a technology for local conditions cannot be uniquely defined in terms of its level of complexity, nor in reference to the sophistication of the scientific theory or method from which it is derived. Rather, it must be defined in reference to the accessibility, mastery, and effective usability of the entire technological packet of which it is a part. The mastery of a technology presupposes that all rights to its exploitation are secured; that all the required skills and expertise for its use are available; and that there is an adequate administrative and institutional structure to integrate it in the indigenous pattern of social and economic development. These conditions are not automatically fulfilled when technology transfers are motivated by strategies of profit and market-share maximizations, nor are they assured (in the case of military technologies) by the goals and ambitions of political leaders. As a result, often the wrong technologies are transferred, subserving the immediate purposes of the dominant actors but creating such well-known problems as dual-economies, mismanagement and waste, resource and environmental depletion, and social and cultural anomy.

36. Problems created by the importation of inappropriate technologies have repercussions in the entire social fabric, not only in the sector immediately affected. In the case of agriculture, this is particularly striking. Here the technologies that proved successful in industrialized countries were often transferred to developing countries in the belief that the same (Western) model of agricultural modernization would work equally well wherever it was attempted. This ignores the fact that in Europe and North America the agricultural revolution has been assisted during more than a century by a parallel process of industrial development. The peasant-farming economy of Europe transformed only gradually under the impact of industrialization. It was at the end of the eighteenth century, for example, that French peasantry was able to liberate itself from medieval servitude and was able to participate in agricultural development. Thereafter, agricultural production doubled in a matter of decades, conditions of famine disappeared, and food intake rose from an average of 2000 to 3000 calories per capita, with animal protein figuring more prominently in the diet. An even faster rate of development obtained in North America benefiting from freedom from the constraints of medieval conditions and from a constant stream of immigrants eager and capable of working the land. Yet even the new agrarian system of the nineteenth century was based essentially on means of production typical of the peasant farming economy (draft animals, organic fertilizers, empirically selected biological materials, etc.). The agricultural revolution taking place in developing countries today occurs under radically different conditions.

37. In the contemporary situation international trade and industry make available mechanized means of transport and land use, food storage, conservation, and processing facilities. National and international markets cannot equitably absorb and benefit from these industrial developments and create widening gaps in productivity and land-use patterns. The less profitable forms of land-use and food production tend to disappear; production concentrates in regions that have physical and economic advantages which enable them to face competition from other sectors and regions. Whereas in Europe and North America agricultural development occurred in tandem with industrial development and was thus able to avoid the worst of its disruptive effects, for example, by absorbing the displaced farm labour in new industrial employment (and later in commerce and in the service sector) in developing countries, agricultural mechanization and Western-style modernization have little or no support in the indigenous economy.

38. In attempts to transplant Western-style agricultural technology to developing countries it is generally overlooked that such agricultural development succeeded in the West because of the simultaneous presence of an already developing industry, the availability of organized centres of training and R and D, and a liberated agricultural work force (peasants in Europe, immigrants in North America). Such a process of modernization can only be realized progressively, adapting the means of production to the absorptive capacity of the economy where the new modes of agricultural production are adapted to the given biological, climatic and economic conditions. The Western model of agricultural development was created for, and adapted to, the temperate zones of Europe and North America and their social and economic conditions. A transfer of the Western model to countries which lack the corresponding level and type of industrial and economic development, and which have entirely different biological and climatic conditions, is condemned to failure.

39. Subjected to pressures for export production and to the competition of world markets, developing country agriculture orients itself to the production of tropical cash-crops such as tea, coffee, cocoa, bananas, ground-nuts, cotton, and others. While its basic foods sector is deprived of systematic and prolonged effort in R and D, such funds as are available are poured into the export sector. But it is the basic foodstuffs that are the most exposed to competition by developed country production. Even in local towns and villages the local produce fetches ridiculously low prices. Under these conditions third world farmers cannot dispose of the financial means to cover their own needs. They are unable to pay the price for the products of modern agro-industry. At best they can acquire improved grains and seeds for export production, in the hope that they will increase effective yields, which is not always the case.

40. The poverty of the farmers and their inability to accumulate savings lead to major environmental and economic crises. They lead to the over-exploitation of lands and forests and to the degradation of the natural milieu. Then it is no longer a question of development, or even of stagnation, but of regression issuing in massive famines and emigration.

41. It is time to realize that modernization on the Western pattern cannot be achieved by the third world except in limited sectors controlled by powerful national and transnational enterprises. Even there, it remains poorly adapted to local biological, climatic and socio-economic conditions. The result is increasing rural unemployment, and higher dependence on the export of cash-crops and import of basic foodstuffs. Hence paradoxically, agricultural modernization reduces the value added locally: the net balance (value of the local production less value of the imports) diminishes. This is particularly true for the highly mechanized sectors of third world agriculture.

42. Energy presents another example of a case in which imported concepts and technologies lead to misuse and waste of local potentials. There is consensus that developing countries will require increasing amounts of energy in years to come. Although they have divergent needs for energy, almost all lack adequate supplies to satisfy the needs of rural areas. To assure an adequate supply of energy for the present as well as for the future, a careful assessment needs to be made of needs and resources. Such assessment must take into account the kind

of development a country intends to pursue and the kind of technologies that are best adapted to achieve its goals. But the current assessment of energy needs, and the transfer of the appropriate energy technologies, manifest serious faults.

43. The following lacunae are particularly important. Primary and end uses are considered, but not the efficiency of the energy to perform useful and needed work. Account is taken only of the flow of energy in the commercial sector of the economy, to the exclusion of production and consumption of such primary energy sources as wood, coal, and plant and animal wastes. These, however, make up a large percentage of the energy use in many developing countries. c/ Last but not least, energy assessment fails to account for regional disparities, which can be particularly important in countries where only some regions have modern transportation and distribution networks. These lacunae in energy assessment introduce a bias into the estimation of future energy needs and can lead to the importation of unadapted and inappropriate energy technologies.

44. The modern and mechanized technologies are not necessarily the most efficient or best adapted to local conditions. In agriculture, no less than in industry, modernization entails great losses in energy efficiency. So-called primitive agriculture invests approximately 1 kilocalorie of fossil fuel to obtain 5 to 50 kilocalories in the form of foodstuffs. Modern agriculture, on the other hand, requires 5 to 10 kilocalories of fossil input to obtain 1 kilocalorie of food output. The difference is due not only to the mechanization of farms but to the entire chain of food production and processing, including changes in dietary habits (reliance on prepared goods, tins, frozen foods) and lifestyles (use of refrigerators, freezers, kitchan machines etc.). An implantation of modern food production-processing-consumption sequences in developing countries reduces their energy efficiency and increases the cost of food production.

45. Industrial development offers similar instances of inappropriate use of science and technology. Several models of industrialization may be distinguished. In one, the dominant role is played by the industries producing durable goods, on a pattern particularly widespread in Latin America. In another, there is an expansion of light industry connected with changes in the mode of consumption, as in many African countries. A third model relies on centralized control and management of the economic system, and a fourth on the dispersion and segmentation of industrial production, as a way to lower the cost of production. Except for the fourth, they all derive from the emulation of a pattern of consumption which conditions and distorts the process of industrialization because of a lack of correlation between type of technology, capacity of capital accumulation, and resource availability. Often the principal goal is to produce locally whatever is needed to satisfy the demands of those who can afford to imitate the lifestyle of the affluent in the developed countries.

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c/ Traditional energy sources account for between 0 and 20 percent of the total energy use in such advanced developing countries as Argentina, Mexico and South Korea; for 20 to 40 percent in twelve other relatively industrialized developing countries including Egypt, Colombia and Peru; they rise to 40 to 60 percent of energy use in 16 countries including India, the Philippines, Thailand and Morocco, to 60 to 80 percent in 12 less developed countries such as Pakistan, Zaire, Kenya and Ghana, and make up to between 80 to 100 percent in the 32 least developed countries. including Bangladesh, Ethiopia, Sudan and Tanzania.

Applications of science and technology are not selected in view of the resources of the economy, the capacity of accumulating savings and income per capita, but in view of their adeptness at satisfying the demands of dominant classes and groups. The traditional sector, excluded from the process, becomes increasingly marginal.

46. Inappropriate forms of industrialization render a disservice to developing countries. They are controlled by transnational corporations and enterprises, many of which make use of capital-intensive methods of production that fail to relieve local unemployment, and adopt policies of profit transfer to home countries that do not contribute to capital accumulation in the host countries. The innovations produced and disseminated by them often remain the exclusive property of the enterprises themselves, and benefit at best a small segment of the population. Beyond the enterprises themselves, there are no capacities in the indigenous economy for research and development. In the case of the third model - using the State as a means of centralized control and management - there is a lesser danger of economic polarization but a risk of creating a privileged social class in the form of bureaucrats charged with the tasks of administration and decision-making. Even in the rationalizing mode of the fourth model of industrial development, there is a danger that transnational enterprises, fearing too great a dependence on local manpower, orient their research and development towards automated production methods. Indications of this are already at hand in the electronics industry, where they threaten the labour market of several relatively advanced developing countries, specialized in this type of production.

47. The desire for rapid industrialization engenders many forms of dependence in developing countries, reinforced by the adoption of technologies that were created in Europe and North America under different socio-economic conditions. These often become inappropriate when transferred to, and used indiscriminately in, the developing countries of Asia, Africa and Latin America.

48. The health field offers further examples of insufficiently available and inefficiently used (though highly developed) science and technology. Recent advances in biomedicine encourage great expectations concerning the improvement of health standards and the lengthening of life expectancies the world over. However, many recent achievements remain unexploited in regard to developing countries. Despite a relative rise in vital statistics, third world life expectancy in the 1970s remains below, or at best equal to, average life expectancy in developed countries in the 1930s. Whereas in the 1970s 10.8 per cent of deaths in developed countries were due to infectious or parasite-transmitted diseases, in developing countries such diseases account for 43.7 per cent of the mortality, taking the largest toll among children and the aged. Further contrasts appear when mortality is analysed by age group. In Latin America influenza and pneumonia are a major cause of death in the infant and 1 to 4-year age groups, while they affect mainly the elderly in North America. Enteritis causes but 0.1 per cent of deaths in North America but is responsible for 9.7 per cent in Latin America. Various tropical diseases, such as schistosomiasis (which affects more than 200 million people in Africa) are prevalent in third world countries only and constitute major health problems.

49. The specific health problem of developing countries consists of a high incidence of transmissible diseases, which combines with widespread malnutrition to produce high rates of mortality in all age groups, especially among infants, mothers and older persons. It also leads to the reduction of the physical capacity of the population at large. Since such diseases are controllable in developing countries as much as they are in developed ones, the poor state of public health in the third world is due to inefficient uses of existing medical science and technology and to unsanitary and inadequately developed socio-economic conditions (lack of balanced diet, clean water, decent lodging, access to medicaments, etc.). Medical research alone cannot respond to the problem. Even larger efforts could result in disappointments (scientific breakthroughs cannot be made on demand), and third world dependence on the industrialized countries could be reinforced. Further financial resources may be required for the development and dissemination of new discoveries; these may not be available to developing countries.

50. Third world dependence is further aggravated by the fact that local researchers often do not have access for their discoveries to major markets, as these are controlled by powerful transnational enterprises.

51. Thus even if modern medicine is capable of treating the greater number of the most problematic diseases affecting developed as well as developing countries, access to its benefits by the latter is limited by the domination of markets by transnational enterprises and by the transfer of medications and technologies in response to the existing distribution of market forces rather than in view of need. Poor health conditions, caused by low levels of socio-economic development, further aggravate this problem.

52. Finally, it should be noted that whatever benefits the adoption of Western-style science and technology may have conferred on developing countries (and we have seen that these are mixed), they are incapable of producing a kind of social and economic development that could satisfy non-material needs. Western countries have paid dearly for their industrialization, in terms of the proletarization of the masses, the marginalization of youth and the aged, the dehumanization of interpersonal relations, and disequilibrium between the individual and the group. In developing countries, traditions still play a pronounced role and are capable of harmonizing social and economic relationships. The problem is to find a model of development, and the science and technology to support it, that is capable of achieving the necessary progress without too high a cost in the sphere of culture.

53. Cultural disruption is particularly threatened by the following - direct or indirect - effects of modern science and technology: transformation of a subsistence into a market economy; disappearance of symbolic values and their replacement by economic values ('objects' become 'things' and 'merchandise'); urbanization and industrialization (family ties are ruptured, social groups become uprooted); superimposition of modern world-views and religions and traditional belief systems (alienation and anomy); the transformation of the traditional means of transport and communication, especially transistor radios (the "revolution of rising expectations"); and the transformation of traditional patterns in the transmission of knowledge

(from family, cohort and community-based systems into formal schools following imported curricula). These factors are interrelated and tend mutually to aggravate each other. The more the traditional values, groupings and beliefs disappear, the easier it is for unadapted foreign cultures to catch hold. (For example, the modern school system feeds the process of urbanization by inculcating in rural children a desire to leave for the cities in search of the values to which it exposes them). In virtue of such simultaneous transformations, both rural and urban masses are exposed to the values and benefits of Western-style civilization without having effective access to its benefits. In place of a stable traditional culture little more is substituted than frustrated expectations, manifest inegalities, and growing socio-economic gaps.

54. Although science and technology themselves should not be considered either the sole agent of these changes or the sole bearer of responsibility for them, clearly science and technology, in virtue of their dominant orientation and the indiscriminate manner in which they are transferred to societies entirely different from those of their origin, are major elements in the persisting underdevelopment of many third world countries. They are also factors in the maldevelopment in a number of industrialized societies and in the inequities which persist and grow in the international community.

55. How science and technology should evolve, and how their achievements should be used and transferred, are vital issues for the future of humanity.

Part III. Science and technology for development - perspectives for the future

56. A creative development within the main body of contemporary science would bring new and more appropriate concepts and theories to bear on problems that beset humanity now and in the foreseeable future. By diversifying the scientific world view and releasing it from the grip of physicalistic concepts, such new development would permit the wellsprings of scientific creativity to flow and enrich not only the storehouses of theoretical knowledge but the development of the human community itself. No longer would the thrust of science be on engineering applications and high-energy manipulations of nature and the human habitat; a new array of fruitful concepts and theories would appear with regard to the preservation and enhancement of the ecological, biological, social, economic and cultural systems within which men and women live their lives and upon which the future of our species vitally depends. No longer would the transfer of technology be concerned mainly with nineteenth and early twentieth century types of industrial processes, bought and sold according to the laws of the market without regard to their impact on man and nature. Given a fresh concentration on the processes and structures of evolution, and on the interdependencies which connect the realm of the living with all levels of organization and evolution, the trend to a monolithic uniformity oriented towards the exploitation of physical nature would be transcended, and replaced by a multiplicity of methods and means aimed at the creation and safeguarding of diversity within the context of worldwide interaction and interdependence.

57. Because of the diversity of experience offered by third world scientists, developing countries would not be passive beneficiaries, but active protagonists of the new trend in science. The scientists of all nations and cultures would play a unique and irreplaceable role in the common endeavour to understand and support the evolution of diverse socio-economic systems in their particular ecological and geographical milieu.

58. People exposed to scientific thinking would come to realize that humanity lives and evolves in the context of the myriad interconnexions of the biosphere, and that its own future is intimately associated with its stability, resiliency and self-organizing capacity. They would become cognizant of the fact that humanity, the only species endowed with the power of conscious conceptual thought and the capacity to purposeivley intervene in the processes of the biosphere, also has the responsibility to control and supervise its interventions.

59. The types of rationality which appeared consistent with the present world view dominating science will appear irrational in the light of science's next development. The creation of an artificial environment, which now appears to liberate mankind from the laws and limits of nature, will be viewed as a dangerous illusion which signals the separation of human communities from their life-supporting environments. Today's economic rationality, which perceives a process of linear growth and accumulation as the ultimate goal of society, will be replaced by social goals that centre on achieving a life of dignity and peace for all people through autonomy within the context of interdependence, and co-operation with respect and understanding for diversity. There will be no internalization of benefits and externalization of costs. The "nuisance costs",

which are currently viewed as unintended side-effects of technological applications, and for which little or no responsibility is assumed, will be integrated in the assessment of costs and benefits. While competition and conflict will not disappear, they will be moderated by the pursuit of shared overriding goals, associated with the maintenance and enhancement of the world community in its planetary milieu.

60. Wherever fundamental research is pursued, concepts and theories foreshadowing the transformation in science sketched here are emerging. At the cutting edge of scientific advance, even the physical universe appears more like an organism than a machine (Heisenberg); more like a cloud than a clock (Popper). Rather than reaffirming that all things are in static equilibrium, or run down towards an ultimate "heat death", fresh research throws light on the physical, chemical, biological and ecological fluxes and constraints which produce "dissipative structures", i.e. systems which maintain and evolve themselves through the constant intake and processing of usable energy (Prigogine). The emergence of energy-accounting, ecosystem modeling, entropic laws in economics, self-organizing concepts in cybernetics, artificial intelligence theory and related concepts demonstrates that the inner logic of science - the internal factors of scientific development - are already leading science towards the needed mode of thinking and understanding. If such logics and factors can be coupled with external, societal motivations to encourage appropriate research and development, science could expand and bring to fruition its new paradigm well before the turn of the century.

61. Paradoxical as it may appear, even advanced military research could be a positive forerunner of these developments. More than in the past, current military research is oriented towards basic science where the distinction between military and peaceful applications is blurred. Although penetrating studies on the conversion of basic research under military programmes into research for human and developmental purposes are yet to be undertaken, it is worth noting that the following areas of conversion are promising: research on missile propulsion and guidance - the peaceful exploration of space; development of high-performance military aircraft - civilian air transport; nuclear propellants for weapons-delivery systems - fuel for peaceful uses; development of submarines and submarine navigation - exploration of the resources of the deep sea-bed; bacteriological weapons - bio-industries, enzymes, ferments; chemical weapons research - development of fertilizers; strategic war games - techniques of control and communication.

62. The existing institutional and physical infrastructure of basic research with military applications could be readily converted into basic research to advance science itself. A continuation of crash programmes, this time for peaceful uses, is likely to yield more benefit to humanity than the accidental spin-offs of military, nuclear or space programmes.

63. A progressive achievement of the goals of disarmament would directly as well as indirectly contribute to useful progress in science and technology. There would be benefits resulting already from the suppression of the negative effects of the arms race; indirect advantages associated with the freeing of material and human resources, as well as the above-mentioned possibilities for converting advanced research under the military umbrella for peaceful purposes.

64. If progress were made towards disarmament, understanding and communication could be restored between scientific communities, replacing secrecy, fear and mistrust. Results could be published and shared, and researchers in all parts of the world could benefit from the findings of their colleagues. The transfer of technology would become freer through removal of the restrictions which now hinder technologies that have potential military applications (electronics, computers etc.). And disarmament would contribute to the decentralization of the science establishment, and its reorientation towards more diversified, flexible, and less wasteful practices.

65. Enormous financial, human, material and energy resources would be freed for peaceful uses. Big science, now oriented towards the combined defence-nuclear-space complex, would be replaced by interconnected appropriate-scale sciences, fed by the liberation of the brain power, the energy and materials, and the huge sums that are currently tied up in military Research and Development.

66. Since scientific research would not be constrained by preconceived notions- only its over-all orientation towards concepts and theories more relevant to the human condition would be encouraged - technological applications of all kinds would continue to emerge from the workshops of scientists. Hence there would be a continued need for technology assessment. Such assessment, while universal, would have to be responsive to variations in local, national and regional conditions, needs and objectives. The goals of societies will continue to vary, according to the ideals and values espoused by their people and their leaders, and to the level of socio-economic development they have attained. Some societies may adopt overcoming poverty as their first priority; others may seek equity above all and the abolition of class exploitation and conflict; while still others may regard the maximization of individual choices and participatory decision-making as their highest goal. Technologies would be assessed in terms of their ability to promote such goals and values within a co-operative system of world development. The general criteria that would apply to technologies in all societies would include the following:

-Equity and fairness: How well or badly is the technology likely to serve the legitimate purposes of all and how will it affect the distribution of values within and between societies?

-Employment and education: What is its likely impact on the job market, and does it require retraining or reeducating the existing work force?

-Energy balance: What are the costs and benefits in terms of energy use and availability?

-Environment: What are the likely effects on the human environment, including the biosphere as a whole?

-Security: What effect will it have on the security of those who deploy the technology as well as on others in the world community?

-Implications for decision-making: What time periods will need to be taken into account in creating, disseminating and using the technology, and will it provide opportunities for social participation?

-Global policy implications: What are the international impacts and consequences of the technology and will it require international machinery to create, control and use?

-The rights of future generations: How will it affect the chances and conditions in which our children and grandchildren will find themselves?

67. The participation of scientists of all countries in scientific research, and the universally practised assessment of technology would overcome today's constraints on technology transfer. Information, the only almost infinitely expandable resource in mankind's possession, would be created in all the research centres of the world. Despite the continued presence of market forces, international technology transfer would become more diversified and equitable. Technologies appropriate to local and regional applications would be produced in all parts of the world, and they would be more fully mastered in the countries in which they are applied. The monolithic domination of a single kind of science and technology would be broken. Technologies would become more appropriate, and such appropriateness would be assured by diversification and indigenous creativity, not by the reduction of the complexity or capital-intensity of a foreign technology. Benefiting from a more equitable world distribution of R and D, and the freer flow of information among scientific communities, technology transfers would become multidirectional. Technical co-operation among developing countries would intensify, and there would be more intense and appropriate flows both between the industrialized democracies and the third world, and between the centrally planned countries and developing countries. Technology transfer from the socialist countries would benefit more fully from the experience of these countries with long-range planning and from the labour-intensive nature of many of the technologies employed by them.

68. In the field of rural development and food production, science can evolve theories with relevant applications based on the concept of cultivated and socialized ecosystems. This approach centres attention on the system's maintenance, regulation and evolution, rather than on the profits which can be derived from it in the short run. The approach will demonstrate that each system should be allowed to recover and secure an autonomous foundation in the production of basic foodstuffs to satisfy the needs of its inhabitants. It should assure a healthy and complete diet of at least 2500 to 3000 calories per person and adequate proteins. It should utilize local resources whenever possible in place of imports. And it should develop all available lands, mobilize the available work force, utilize locally available energies and fertilizers, and develop locally adapted plant and animal varieties.

69. It follows that the revitalization of rural economies calls for the restoration to peasants and farmers lands dominated by big landowners and agri-businesses. It requires the opening of unexploited land reserves, and the enlargement of the areas of cultivable land by means of soil management and irrigation. Mechanization will be indicated only where the technologies are adapted to local social and cultural patterns; where they can be locally financed; and where the rural work force liberated thereby can find alternative types of employment. Thereby the integrity and continuous development of rural systems can be assured, and the current polarization between modernized and subsistence sectors overcome.

70. The rural ecosystems developed by humanity are highly differentiated and cover a wide range of conditions and means of cultivation. There is a large diversity in biological materials, in domestic animals, cultures, land use patterns, and in skills, techniques, and implements. Science can study the optimum utilization of each variety of system, in view of its specific combination of physical, social, cultural and economic conditions. Such research and development are a precondition of saving the quickly disappearing and deteriorating foundations of indigenous peasant and farmer economies and thereby provide a secure basis for the survival and self-reliance of peoples and societies.

71. Rural ecosystems can be permanent sources of considerable supplies of safe energy. Among the many renewable energy sources the least developed to date is the utilization of photsynthesis. The bioconversion of solar energy through photosynthesis yields ten times the world consumption of energy each year in the form of biomass. Technologies based on photosynthesis make use of water and sunlight, resources that are harmless and widely available. The technologies can produce fuels (combustibles and carburants) for direct conversion into energy, as well as raw materials for chemical, pharmaceutical and food products. d/ The use of such technologies in the third world is particularly auspicious: most developing countries have a high level of insolation; the resulting industries can be decentralized and do not require much in the way of additional energies; and the technologies can often be developed on the basis of traditional procedures (as they were in Japan).

72. The availability of options other than fossil and nuclear energies calls for careful energy assessment, as part of the over-all system of technology assessment. Energy assessment would consider not only supply and assume that demand is constant (as it does currently) but take into account need and select the most efficient way of meeting it. For example, rural.energy needs

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d / There are two ways to produce fuels through photosynthesis: by means of the biomass, and directly. The biomass can be converted by means of gasification, combustion, and fermentation to produce methane, alcohol and similar substances. The direct production of energy includes the biophotolysis of water, the production of hydrogen from algae and from vegetables associated with bacteria, and from techniques now in development using the ability of algae to produce hydrocarbons.

Techniques of photsynthesis to produce industrial raw materials make use of agricultural by-products such as grass, wood, straw and molasses, fermentation and enzyme technologies, and plant substances for medicinal purposes. In addition, photosynthesis can also be used to produce proteins and fertilizers through nitrogen fixation; and an array of technologies are in development which reproduce photosynthesis in artificial systems through the incorporation of organic molecules and chemical substances.

in developing areas are quite different from industrial and urban needs and can be satisfied by low-cost means such as developing more efficient stoves and pumps, and renewable energy sources. Energy assessment would match needs with supplies and establish priorities based on an integrated plan for social and economic development. Hence it would occur on the level of political decision-making rather than on that of specialists in separate energy domains.

73. Energy R and D would be oriented to the achievement of three principal goals: first, the enhancement of efficiency in energy use (for example, through improved coal or wood burning stoves); secondly, the exploration of traditional and non-conventional energy sources, such as biomass, solar, wind, and related technologies; and thirdly, the development of small-scale applications capable of decentralized use in villages and thinly populated areas. Tomorrow's science of energy would extend beyond today's energy field, encompassing the entire sphere of economic activities. These would also be measured in terms of energy inputs, outputs and wastes. Science and technology would focus on minimizing energy input per output, making use of renewable or plentiful energy sources, and creating end-use technologies suited to the diversity of real energy needs.

74. Industrial development will similarly benefit from new developments in science and the purposive assessment and use of technology. Technological innovations will not be sought for their own sake but be carefully limited to areas where they can enhance efficiency in the use of the available physical and human resources. Thereby development would lead to the depolarization of societies by closing consumption and lifestyle gaps. Preferred types of consumption would have two characteristics: they would be based on the existing endowments and authentic traditions of societies; and they would absorb new products and processes within an integrated development of all segments of the population.

75. Science policy would approach the problems of public health within the framework of organic and self-reliant development. It would break the vicious circle of poor health retarding development and underdevelopment leading to poor health. It would recognize that the health research requirements of developing countries are often less severe than estimated. New discoveries do not necessarily lead to more complex technical apparatus and procedures; they may also bring simplified solutions. On the theoretical level new knowledge is a synthesis and brings deeper understanding; its results can be adapted to a wide variety of needs and resources. Small-scale and inexpensive applications are often as possible as large-scale and capital-intensive ones; the rationale of current choices is political and economic, not only scientific. It is imperative, therefore, that developing countries develop their own health R and D capabilities, and integrate their results within a systemic approach to social and economic development.

76. Many countries remain associated with their cultural tradition, and benefit from its humanizing and stabilizing effects despite the incursions of imported modernism. In the future, science would investigate the contribution of cultural traditions to society, and to science and technology, and not only the effects of science and technology on traditions. Oral traditions would be saved from

extinction and their time-honoured wisdom would be integrated in social and cultural development. Education will be liberated from the grip of imported and often irrelevant curricula and will place emphasis on the value of cultural traditions and on the natural endowments of the environment. The purpose of education will be assessed in the context of science's evolving knowledge of specific social and economic systems; education systems will be designed to contribute to such knowledge locally as well as to handing it down to the next generations.

77. In its next development, science would restore a central place to human beings in the process of development, and situate development in the context of the self-maintenance and self-transformation of the biosphere. It would replace the logic of a subsystem - the economy, narrowly conceived - with the logic of the biosphere as a whole. Planetary constraints would be integrated in the calculation of the benefits of organized human activities in the sphere of the economy as well as elsewhere. Multiple levels of decision-making and implementation would be distinguished, from the local to the global. Centralization and decentralization would no longer be considered opposites; each would find its proper use according to the type of problem and the corresponding level of decision and execution. Institutional structures to assure decision-making functions would be developed on regional and international levels, to monitor scientific and technological developments; to assure a free flow of information; to co-ordinate science policy and the assessment of technology; to analyse the pattern of needs and supplies; to co-ordinate the required international agreements; to identify new or still unexploited resources and promising fields for scientific exploration.

78. To actualize the promise inherent in science and technology for the benefit of humanity, there must be a conscious and purposive guidance of science and assessment of technology. Science and technolgy should be neither embraced as they are nor rejected out of hand: they should be evolved to combine the pursuit of truth and objectivity with human relevance and benefit.

79. The evolution of humanity will become truly self-conscious and responsible when it is combined with the conscious and responsible evolution of science and technology.