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The Sussex Manifesto: Science and Technology to Developing Countries during the Second Development Decade.

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The Sussex Manifesto:

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DRAFT INTRODUCTORY STATEMENT FOR THE WORLD PLAN OF ACTION FOR THE APPLICATION OF SCIENCE AND TECHNOLOGY TO DEVELOPMENT, PREPARED BY THE " SUSSEX GROUP " *

Introduction

1. The World Plan of Action for the Application of Science and Technology to Development starts with the premise that the developing countries must have their own scientific and technological capability. This indigenous capability is necessary not only for increasing production, but, what is more important, for improving the capacity to produce. This argument is developed in section I of the statement.

2. There are vast gaps in the developing countries between actual production and the production potentials through the application of science and technology. An analysis of this situation, which is essential as a basis for policy proposals, is contained in section II. The underlying problem arises from the international division of labour in science and technology and the present massive orientation of world scientific effort to the problems and objectives of interest principally to the advanced countries. The consequences of the inherent weakness of scientific institutions in the developing countries are exacerbated because advanced country oriented science has negative effects through the " external brain drain " and through the influence which the centres of scientific interest in the advanced countries have on the orientation of scientific efforts in the developing countries. There is, in other words, an " internal brain drain " of scientific workers in the developing countries, who tend to work on problems which are irrelevant to their environment. The total result is that the composition of the stock of scientific and technological knowledge in general is becoming proportionately less and less suitable for direct use in the developing countries; in addition, the development of new technologies, particularly directed towards producing synthetic substitutes, has adverse economic consequences for the developing countries. At the same time, the developing countries have specific problems of access to foreign technology.

3. These are immediate causes of the gap between potentials and actual realizations. In addition, there is the fundamental difficulty that the organization of the economy in the developing countries is often unfavourable to the application of science and technology in production.

4. The inference is that a major change is needed in the international division of labour in science and technology and in the orientation of world scientific effort. This reorientation of effort, which will require the allocation of the scientific resources of the advanced countries, is necessary both to tackle urgent problems facing the developing countries and to create a context in which the indigenous scientific effort of the developing countries can be built up in an orderly way

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and related to their environmental requirements. In section III, the main policy proposals for achieving these ends are analysed. There are four main groups of proposals which constitute the framework for the World Plan of Action. These proposals are interdependent in the sense that the effect of implementing any one of them will be vitiated if the others are not also implemented. Indeed, a restricted effort in tackling the problem may merely exacerbate existing problems and result in a waste of scarce resources.

5. First, the developing countries must build up their indigenous scientific and technical resources. It is proposed that the research and development (R and D) effort of the developing countries should be increased from the present level of about 0.2 per cent of gross national product (GNP) to about 0.5 per cent of GNP. This target is a rough approximation and has to be disaggregated if it is to have any operational meaning. Other scientific and technological inputs should be increased in similar — or even greater — proportion. But this increased expenditure will yield economic and social benefits only if various measures of institutional reform are properly executed. In particular, the build-up of science and technology must be planned and oriented to requirements. This requires new policy-making institutions. At the same time, universities and other higher educational institutions need to be reformed with a view to increasing the supply of highly qualified manpower. Thorough reform of research and other scientific organizations is also needed so that the manpower can be rationally and usefully employed.

6. Secondly, the advanced countries ought to give direct, financial and technical assistance to the build-up of indigenous science in the developing countries. This assistance should reach 0.05 per cent of their GNP during the Second United Nations Development Decade, which would imply that about 5 per cent of their total aid would be for science and technology.

7. These various efforts by themselves would have a limited effect on the orientation of world scientific effort, and consequently on the problems which arise from the present orientation. A reorientation of the R and D and other activities of the advanced countries is also essential. It is proposed that the advanced countries should devote about 5 per cent of their total R and D expenditure to the specific problems of the developing countries during the Decade. The reorientation will, however, require a change in the context of education of scientists in the advanced countries and direct action to build " science for development " into the professional recognition and reward structure of the scientific community.

8. Thirdly, there are problems of communication and access which need specific solution. On the one hand, the scientific and technological effort of advanced and developing countries must be " coupled ". On the other hand, the problem of access to technology must be solved. On this latter point, it is suggested that an international technology transfer bank may be a valuable if partial solution.

9. Finally, it is stressed that the full realization of the economic and social benefits of these policies depends upon complementary institutional changes in the developing countries themselves.

I. Science and technology are necessary to development

10. The advanced countries have found that science and technology are extremely powerful tools which help them achieve their national objectives. As a consequence, large resources amounting in many advanced countries to 2 and even 3 per cent of GNP are currently allocated for research and development. Many times this amount are additionally spent in applying the results of this R and D.

11. By contrast, modern science has not been pursued to the same extent in the developing countries. This has had far reaching effects not only on their ability to develop indigenous technology appropriate to their local needs, but also in their ability to absorb foreign technology. It has also meant that they have been unable to capitalize on the social role of science as a modernizing force. The world view of science, which implies that the laws of nature can be understood and that this knowledge can be used, is still alien to a large segment of people in the developing countries.

12. The spectrum of activities covered by "science and technology" is broad. Not infrequently they mean different things to different people. It is therefore important to define what we mean by science and technology.

13. We have classified the various levels of scientific and technological activity which require systematic support in the development process into four categories. Any such classification is bound to be arbitrary and do violence to the real complexity of society, but some breakdown is essential for serious analysis and policy formulation.

(1) At the heart of "the science and technology system" are those activities which are generally known as "research and experimental development" (R and D or NIOKR in the Soviet system of concepts). This group of activities has been fairly closely defined by UNESCO and OECD on standard international conventions, and has been measured in most OECD countries and some of the developing countries. The definitions stress the original and experimental nature of R and D work. However, some countries have included within this category activities which do not properly belong to R and D narrowly defined, such as information services or geological survey work. We have preferred to keep to the strict definition of R and D, and to classify these other activities as a second category of "scientific and technological services" (STS). Expenditure on STS in the developing countries might often be a multiple of R and D expenditures, perhaps by a factor of two, but there are no systematic statistics.

(2) We have defined "scientific and technological services" to include the following activities closely related to R and D:

Scientific library and information services;

Scientific testing and standards services;

Museums, zoological and botanical gardens;

Geological, geophysical, meteorological and natural resources, survey work, including mapping;

General purpose social and economic data collection;

Technical and scientific advisory, consultancy and extension services, including patent offices, and related activities.

Whereas R and D has been fairly rigorously defined and measured, this is not the case with "scientific and technological services" (STS). Preliminary definitions have been suggested by UNESCO in its publication entitled *The Measurement of Scientific and Technological Activities.*[b] In general, we follow their provisional scheme. However, some activities which are very broad in scope and concerned with diffusion and application of science and technology in the widest sense, we have classified in two other categories.

(3) Scientific and technical education and training and popularization of science and technology through the mass media. The UNESCO scheme includes university services and technology education in STS.

(4) Application of science and technology in industrial and agricultural production and services of all kinds, including routine design, engineering, production control and marketing, routine medical services, administration and so forth. The UNESCO scheme includes design and engineering in STS.

14. Policy for science and technology in the narrowest sense is concerned primarily with decisions relating to research and experimental development. But it is our contention that this decision-making must be closely related to over-all strategy for economic and social development. Policy for science and technology in this broader sense is concerned not merely with generation of new knowledge in the R and D system, but also with the dissemination and application of existing and new knowledge throughout the economy, and with the reciprocal interaction between science, technology and the economy. Policy in this broad sense will be concerned with all four of the categories which we have defined.

[b] Christopher Freeman, *The Measurement of Scientific and Technological Activities*, "Statistical reports and studies/rapports et études statistiques" (UNESCO, Paris, 1969).

Indigenous capacity for science and technology in the developing countries

15. Science as the means of understanding the natural environment, and technology as the means of controlling and exploiting it, are essential to the efforts to increase production in the developing countries and, above all, to make such increases cumulative and self-sustaining. Every "model" of development implicitly presumes the application of science and technology to production in agriculture, industry and services, in whatever other respects the models may differ. The increase of land and labour yields in the agricultural sector especially depends on higher levels of understanding about the environment and on the technological means to exploit it. Industrialization, by definition, means the wholesale introduction of new technology. The same applies to other sectors, such as transport, power etc., and to social sectors such as health and education. In addition, scientific and technological knowledge in principle provides an escape from the limitations of poor natural resources to much larger increases in productive power than could otherwise be conceived.

16. This is the most obvious sense in which science and technology are necessary to development. But there is much more to be said. Development means more than a quantitative increase in production. An increase in production would in fact be more a consequence of development than its essence. In other words, development is more than growth. In his proposals for the First United Nations Development Decade, the Secretary-General expressed this by saying that the real problem of development was not to increase production but to increase the capacity to produce. This capacity ultimately is inherent in people. It depends on people with the outlook, knowledge, training and equipment to solve the problems posed by their own environment, and thus control their environment rather than be controlled by it. This capacity has grown in the now richer industrialized countries by a historical process, sometimes natural and slow, sometimes planned and even forced, often aided from abroad, but always also indigenous.

17. The result of this historical process has been a qualitative social change. People in these societies are aware that the environment can be understood and exploited; and a large number of them are trained in the systematic use of scientific method in order to do so. It is this awareness and these skills which are necessary to development and which underlie the application of science to production.

18. From the outset, then, we reject the idea that the existing international division of labour in science is adequate for development. It provides no basis whatsoever for development; amongst other things, the less developed countries must have an indigenous scientific capability.

19. The idea that there is no problem about the existing international distribution of scientific capability is based on the view that the developing countries can rely on technologies from Governments and industries in the advanced countries. On this view, all that is needed is to clear the channels for the "transfer of technology". But the transfer of technology though necessary, is not an alternative to the development of local science. It is difficult for a developing country without a science and technology capacity of its own, and particularly without the trained people involved, to know what useful technology exists elsewhere, to understand it, to select it, to adapt, to absorb, to repair and maintain, to operate. Only in the short run, can these tasks be done from the outside. As so often in development, it is a case of "to him who has will more be given". If a nation has built up its capacity in the field of science and technology, it is also in a much better position to utilize what exists elsewhere. So all the considerations converge on this priority task of implanting into the developing countries themselves the research and technical capacities required.

20. In addition, of course, the ability to use transferred technology as the basis of further innovations — which is crucial to maintain competitive efficiency at rising income levels — depends entirely on local scientific capability.

21. Our starting point is, therefore, that there is a fundamental necessity to build up indigenous scientific capability in the developing countries. This capability is necessary if the people of these countries are to be able to define, analyse and solve environmental problems and escape from the narrow commitment to environmental influences that is characteristic of their present situation. We argue that this local capability is necessary in any case, even if a large number of specific problems can be solved by technologies that have already been developed or could be readily developed in advanced countries.

22. But the resources of the advanced countries are equally essential. The less developed countries face many immediate and pressing problems which require a scientific and technical " input ". It is quite certain that they will not be able to build up their own scientific capabilities rapidly enough to provide this input in the near — or medium-term future — even if there is a high level of commitment to the development of science. The only way to solve these problems in a reasonable length of time is to mobilize scientific resources from the advanced countries.

23. In fact, there is probably a reasonable international consensus on these points. The problem is that, in spite of this and in spite of some efforts to apply science to the benefit of the developing countries, so little has actually been achieved. We know that the potential for increasing production in the developing countries is very large; and yet, despite the existence of the scientific means for getting these increases, so little has happened. It is this situation which must be diagnosed and understood as a basis for future action.

II. There is a vast gap between potentials and realization

24. We shall examine four main elements which between them have been highly responsible for the limited impact of science and technology in the developing countries. These are:

(*a*) The weakness of scientific institutions in the less developed countries;

(*b*) The " weight " and orientation of advanced country science and technology and its impact on the developing countries;

(*c*) The problems of access by the developing countries to world science and technology;

(*d*) The obstacles to the application of new technologies arising from underdevelopment itself.

25. There is, however, an additional factor which must be kept in mind throughout the following discussion. This is the very lop-sided nature of the present international division of labour in science and technology. We can give some rough quantitative guides to the international distribution of R and D efforts.

26. Table 1 indicates that 98 per cent of the above R and D expenditure outside the socialist countries is made in the developed market economies. It is possible that the developing countries have a somewhat larger share of world STS expenditure, since the proportionate expenditure on non-R and D STS is probably higher in the developing than in the developed countries. It is also possible that the proportion of world R and D manpower in the developing countries is greater than the proportion of expenditure, since R and D expenditures per scientist (including the salaries paid) are typically a good deal lower than in the developed countries. Finally, the R and D expenditures of centrally planned economies, which are not available to us, should be included to complete the global concept. But, we do not believe that these caveats would lead to much modification of the picture given in the table.

TABLE 1. DISTRIBUTION OF R AND D EXPENDITURES IN THE WORLD (EXCLUDING CENTRALLY PLANNED ECONOMIES)

Country group	*United States*	*Other developed market economies*	*Developing countries*
Percentage of world expenditure	70	28	2

SOURCE: Calculation based on OECD data for the developed market economies; on UNESCO and Pan American Union (PAU) data for developing economies.

27. The international division of labour in R and D is profoundly influenced by the national political and economic objectives of the advanced countries. Table 2 shows the distribution of R and D expenditures in the developed market economies by major objectives.

TABLE 2. PERCENTAGE DISTRIBUTION OF R AND D EXPENDITURE IN OECD COUNTRIES BY MAJOR OBJECTIVES, 1964

Atomic	*Space*	*Defence*	*Sub-total*	*Economic*	*Fundamental and welfare research*	*Specific problems of developing countries*
7	15	29	51	26	22	1

SOURCE: OCED data in *The Over-all Level and Structure of R and D Efforts in OECD Member Countries* (Paris, 1967).

Although the developed market economies make certain expenditures on R and D related to specific problems of the developing countries, these expenditures, on available evidence (from the OECD International Statistical Year for R and D), are very small, amounting to less than 1 per cent of gross expenditure on research and development in all cases.

28. The extreme lop-sidedness of world R and D expenditure and of science and technology efforts, as well as its orientation towards certain major objectives of the advanced countries, do indeed have some beneficial " fall-out " effects upon the developing countries. But, in the main, they are responsible for the operation of the following specific factors accounting for the gaps between realization and potentials.

THE WEAKNESS OF SCIENTIFIC INSTITUTIONS IN THE DEVELOPING COUNTRIES

29. The global analysis of the international distribution of R and D expenditure shows that, in aggregate, the developing countries make very small allocations to these activities.

30. At the same time, there is a strong suspicion that the minimal expenditure of the developing countries is also less productive than the concentrated R and D activities of the advanced countries. They are less productive from the scientific point of view in the sense that the output of significant results seems to be small in relation to input of resources; they are less productive economically because the scientific work in question is often of little economic or social relevance to the country's own problems and also because the rate at which results are applied is low. Even the presently meagre effort of the developing countries in R and D yields less than optimal benefits to the countries concerned.

31. Low productivity is partly a consequence of problems in organization of science in the developing countries. University research is frequently " squeezed out " by heavy teaching and consulting loads; applied work in government institutes suffers from lack of finance, red tape and lack of co-ordination between government departments or even within them. Even where there is an apparent concentration of scientific resources, say in agriculture, this hides a reality in which the total research activity consists of a large number of small projects bearing little relation to one another.

32. The weakness of scientific institutions in the developing countries extends to survey, testing and data-gathering activities. It is also reflected in the general shortage of scientifically and technically qualified people engaged in production activities. Finally, one immediate reason for the limited application of scientific results is generally presumed to be the weakness of the extension and service types of institutions in the developing countries.

33. These observations suggest that when qualitative factors are taken into account, the effective use of science and technology resources is even more lop-sided than the international resource distribution would suggest, and that the industrialized countries have a vast preponderance. But the matter does not rest there. The sheer weight of advanced country science, as well as its superior quality, has crucial effects in the developing countries.

34. There are three main ways in which science and technology in the advanced countries affect the developing countries. We shall examine them under the headings: (1) the " internal brain drain "; (2) the " external brain drain ", and (2) the composition of the stock of knowledge and its economic consequences.

The " internal brain drain "

35. The scientific institutions in the developing countries are weak and so particularly are policymaking and planning institutions dealing with R and D and STS. In addition, as we shall state later, there is very little demand or perception of the need for science and technology in the society as a whole. In consequence, the local influences on the orientation of science and technology in the developing countries are weak.

36. In these circumstances, the weight and orientation of world scientific effort has a preponderant influence on the way science develops and is oriented in the developing countries. Many observers have noted how scientific and technological activities in the developing countries tend to form an " enclave ".

37. Moreover, it is clear that, even in the fundamental sciences, the orientation of science in the advanced countries is strongly influenced by the major national objectives to which the scientific efforts of the advanced countries are intimately linked; objectives like defence, space exploration, the development of atomic power and so on. (See table 2.) By implication, the orientation of science in the less developed countries is often influenced and determined by objectives which are external to the countries themselves and which have little enough to do with the requirements of development. Sometimes the aid activities of the advanced countries in relation to science in the less developed countries have reinforced these contradictory tendencies.

38. The result is a phenomenon which we shall refer to as the " internal brain drain ", whereby a substantial part of the scientific work going on in the developing countries, in addition to being under-financed and poorly organized, is irrelevant to the environment in which it is being done.

The " external brain drain "

39. A more immediately noticeable consequence of the intensive development of scientific and technical activities in the advanced countries is the rapid growth in demand for scientific workers it generates: the " external brain drain " is no doubt encouraged in considerable measure by this growth in demand. The " external brain drain " must also be associated, however, with the incapacity of scientific institutions in the developing countries to absorb and use scientific workers.

40. The large-scale migration of highly qualified personnel from developing to developed countries is of recent origin. However, the volume of that movement (net) may already be approaching 40,000 per year and, as such, is larger than the movement of technical assistance personnel from developed to developing countries. Under prevailing conditions, this " brain drain " is likely to increase over the next decade. The United States Department of Labour has estimated that 380,000 professionals (as well as about 600,000 middle-level workers) would enter that country between 1965 and 1975. A substantial proportion of those people will come from developing countries, and, in addition, further tens of thousands will be emigrating to other developed countries.

41. The output from the third level education is increasing in the developing countries at roughly two to three times the rate of aggregate economic growth; in some countries the difference is substantially greater. Unless some way is found of bringing the employment possibilities for trained people into line with their increasing numbers, this means educated unemployment and/or international migration.

The adverse composition of the stock of knowledge

42. The picture that comes out of the analysis so far is of a relatively very small scientific and technical capability in the developing countries, which is undermined by organizational weakness and also by the varied responses of scientific workers in the developing countries to the mass of attraction that advanced country science constitutes. The environmental conditions in the developing countries receive scant attention. A consequence is that whilst the stock of world scientific and technical knowledge is certainly increasing at an accelerating rate, its precise composition is such that there are large gaps in scientific and technological knowledge that would be particularly relevant to the developing countries. The work of the Advisory Committee for the Application of Science and Technology to Development has been concentrated to some considerable extent on identifying these gaps. The list of priority areas where the Committee specifies that new knowledge is urgently required is in one sense a demonstration of the important technical problems which have been left neglected and unsolved by the present concentration and orientation of scientific effort to the political and economic objectives of the advanced countries. Perhaps one of the contrasts is found in the relatively vast knowledge we have of technical development in agriculture in temperate as opposed to tropical regions.

43. In addition, the stock of scientific and technological knowledge is proportionately less and less directly suitable for use by the developing countries. This is particularly true where the knowledge in question is about the application of scientific principles. First, the new technology is not "appropriate" for the developing countries in that it emphasizes production methods which are suitable for capital-rich, and unskilled-labour-short countries, i.e., the richer countries of today. The developing countries by contrast are short of capital and skills, but relatively rich in labour. This discrepancy between the resource-mix for which modern technology is increasingly designed, and the actual resource-mix in the developing countries places them at an increasing disadvantage. Secondly, the available technology emphasizes production on a large scale whereas the initial markets of developing countries (even including their realistic export markets) are usually small in economic terms. Thirdly, product design of plant, equipment and consumer goods emphasizes the needs of the richer industrialized countries. Finally, a very great deal of world scientific and technological effort is concentrated in industries which simply do not exist in the developing countries, and which will not exist there for many years to come.

44. But the problem is not only that the needs of the richer countries are dominant, but that the products of scientific and technological progress which result from this concentration are often such that they exert harmful "backwash" effects on the economies of the developing countries. Apart from the "brain drain", the development of synthetics replacing the natural raw materials produced in the developing countries is an important case in point.

45. Probably about $1,000 million *per annum* are being devoted to R and D on synthetic materials (plastics, fibres and rubbers) in the chemical industries of the advanced countries. This is almost equivalent to the entire expenditure on research of all kinds in the developing countries and is, of course, very largely devoted to new materials of primary interest to the advanced economies.

46. When the advantages and benefits of further development of synthetic substitutes are considered, the harmful effect on the producers and exporters of the natural primary commodities thus displaced is not normally taken into account. The results are all too apparent: the shares of such natural commodities as rubber, cotton, tin, vegetable oils, in total world consumption and trade have declined rapidly, partly as the result of research and development devoted to the economy in the use of such materials and/or the development of synthetic substitutes for them. Work on the development and improvement of natural primary commodities of special interest to the developing countries does not receive the emphasis it deserves.

The problems of access by the developing countries to world science and technology

47. A further problem is that the developing countries have highly imperfect

access to the body of world scientific knowledge and also to world technologies.

48. Easy access to sources of information, and effective " coupling " with these sources, are essential to the efficient functioning of the science and technology system in any country. This " coupling " function has to be done across national and cultural boundaries which present exceptionally acute problems. Thus, studies of information flows in the R and D process generally conclude that information derived from formal literature search and from formal information systems account for relatively small proportions of total information inputs. The informal communication network is of critical importance, including direct personal contact, telephone calls and correspondence. This is one of the critical advantages of the industrialized countries in the workings of their science and technology systems, and it poses special problems for the developing countries, which have to establish these informal links with the scientific community in the advanced countries.

49. Access to world technology on the other hand raises special problems. Much of the technology in question is in private ownership, that is, it is patented or at least secret. In general, the companies owning the technology " release " it to the developing countries only if they are able to make direct investments there. The companies show a marked preference for direct investment as a means of exploiting the technological advantages in the developing countries, rather than entering into agreements with independent firms in the developing countries themselves. The main reason for this seems to lie in the lack of capital and skills in potential conterpart companies and also in the risks of inefficient operation of the new techniques by independent enterprises in the developing countries. The net results are that the flow of proprietary technologies to the developing countries are dependent on their capacity to bring in foreign investment (which is limited) and that the development and competition of domestic industry is hampered by lack of access to new techniques.

50. Even when technology is non-proprietary, there are problems of access for the developing countries. They have to obtain technology in an embodied form, that is, by importing capital goods and/or building up capital goods industries of their own. In these tasks, they are hampered by lack of domestic savings and lack of foreign exchange. The latter is, in part, the result of world science and technology effort which, as we mentioned before, has tended to reduce the earnings of the developing countries from the exports of primary products. On the other hand, the volume and costs of importing capital goods have been going up, partly reflecting the increasing sophistication of embodied technology. The capital goods which the developing countries import are not only more expensive vis-à-vis their exports, but, in most instances, malsuited to their resource endowments.

Under-development as a basic obstacle to the application of science and technology

51. Whilst these various factors are important in explaining why it has been so difficult to exploit science and technology for the benefit of the developing countries and why the growth of science and technology has had adverse consequences for them, they are really only proximate causes. The real causes lie deeper, in the nature of under-development itself. In brief, many of the structural and organizational characteristics of the developing economies are antithetical to the application of science and technology and, by the same token, prevent the development of what might be termed a " realized demand " for scientific and technical knowledge. It underlies both the limited transfer of technology into local industries in the developing countries and also the weak development of local scientific institutions and their marked susceptibility to orient their activities in line with external influences. This is a particular aspect of the " vicious circle of under-development ": the resolution of many of the problems of the developing economies requires the application of science and technology to production, yet the conditions of under-development itself tend to limit the possibilities for their application.

52. Hence, whilst science and technology are certainly necessary inputs for development, their application in the developing countries nearly always requires certain important structural and developmental changes as concomitants.

III. A major reorganization of world scientific effort is needed: objectives, strategy and implementation

53. On the one hand, we have argued that scientific and technological efforts in all four of the categories defined in section I are necessary to self-sustained development and to creating the capacity to produce. This requires an indigenous science and technology capability in the developing countries and a major reorientation of world scientific effort.

54. On the other hand, the analysis shows that this will not happen automatically. The application of science and technology in the developing countries cannot be left to chance. If it is, nothing constructive will happen or, more probably, the ensuing development of world science will have negative effects on the developing countries. There are self-reinforcing tendencies in the international scientific system which work against the development and exploitation of science and technology in the developing countries.

55. In other words, the question must be approached consciously and systematically; scientific and technological effort must be directed to the objective of development in a planned way, just as the application of science to space conquest has been planned.

56. But the planned application of science and technology to the problems of the developing countries is particularly difficult because the planning has an international dimension; it will not succeed without international co-operation. The necessity for international action arises simply because the developing countries cannot solve the problems arising from the present international division of labour in science and technology by their own efforts.

57. This has important implications for the discussion of policies to resolve the present crisis. In order to exploit the potentials of science and technology in the developing countries, various policies are needed both in the developing countries themselves and in the advanced countries. By implication, these policies are linked; they are all equally necessary and the effectiveness of any one of them will be vitiated if the others are not also undertaken. The main policies needed fall into four groups:

(*a*) Policies in the developing countries to build up their indigenous scientific and technological capacity in an orderly way;

(*b*) Policies in the advanced countries to support these efforts and particularly to reorient world scientific and technological efforts;

(*c*) Policies to provide the developing countries with better access to world science and technology; and

(*d*) Policies to resolve the problems of economic organization which prevent the rational application of science and technology to production in the developing countries.

Developing country efforts to build up indigenous capability in science and technology

58. Indigenous scientific capability is essential for creating the capacity to produce in the developing countries. The present weakness of their scientific efforts reflects a random growth of scientific activity, which is inevitable if things are left to take their course in societies where there are no pressures of demand for scientific and technological knowledge. This means that the development of science and technology in the developing countries will have to be much more carefully planned than in the past.

59. The objectives that will have to be met as a basis for this planned build-up may be inferred from the preceding analysis. They are:

(*a*) The formulation of effective science policies;

(*b*) The provision of highly and appropriately qualified manpower for R and D and relative activities. The university system must be able to provide science education to the post-graduate level and to relate research to the context of development;

(*c*) The execution of R and D supported by necessary STS;

(*d*) The application of new techniques in production, and the promotion of new attitudes based on scientific method amongst management, workers and the total community.

Institutions for formulating science and technology policies

60. The necessity for policy-making institutions is implicit in everything we have said and particularly because the scientific and technological effort has to be planned in the developing countries. Science policy institutions must not be allowed to become merely a façade for scientist pressure groups who, under the guise of national commitment, are really mainly interested in getting more resources put into their own fields of interest.

61. What is needed is an institution or institutions which can fulfil the following functions:

(*a*) Co-ordination of science and technology strategies at senior executive levels of Government with national economic and social planning;

(*b*) Co-ordination with the science and technology strategies of other countries. National science and technology policy cannot fail to take into account what other countries are doing, or fail to consider the implications their programmes may have for national programmes;

(*c*) The establishment of scientific activities which relate to the development effort of the country and the orientation of scientific activities in directions most relevant to national development;

(*d*) Integration or "coupling" between research effort and the process through which this effort is translated into economic applications;

(*e*) Establishment of policies towards technology transfer.

62. The requirements for science policy institutions have been analysed in some depth by UNESCO; their work is an invaluable guide to the institutions which are required. Unplanned science expenditure in the developing countries will simply increase the "internal brain drain". Planning should relate science and technology activities to development objectives and should specifically take account of complementarity between indigenous R and D and the importation of technology.

The reform of the education system so as to provide appropriately qualified workers for scientific and technological activities

63. The accelerated development of science and technology will put pressure on educational institutions and particularly on post-graduate education. There is little doubt that the real constraint to the development of indigenous R and D in the developing countries is the scarcity of manpower. This reflects acute limitations in the university organization, which undermine the possibility of maintaining very high growth rates of R and D expenditure.

64. The problem in the developing countries is not only that the stock of scientifically qualified manpower (and particularly R and D manpower) is very small (which makes high growth rates easier to conceive), but that the institutional capacity to produce more is also small (which makes the high growth rate very questionable even though the absolute increases are not large). Data on proportions of qualified personnel are scanty; and there is very little information on the past growth of the stock of scientific and technical manpower. We can, however, get some idea of the potentials for increasing stocks of total scientific and technical manpower by looking at proportionate additions to stocks of scientists, engineers and doctors. Some very rough data available for Middle Eastern and north African countries suggest that proportionate additions of 8 to 12 per cent are fairly typical. Data on post-graduate outputs are much more limited than general data on graduates. Fragmentary information from OECD studies suggests that additions of post-graduate trained manpower to stocks of scientists engaged on R and D are about 5 to 10 per cent in certain southern European countries.

65. In other words, in spite of the small absolute size of the stocks of scientists, it seems unlikely that it would be possible to increase these stocks by much more than 10 per cent *per annum* over ten years unless there is a reform of the universities or unless educational facilities in the advanced countries can be used more intensively without increasing "brain drain" losses. This latter possibility requires very considerable changes in the present world scientific content.

66. University reform leading to an increased rate of output of graduates and post-graduates for R and D is evidently necessary. It is, however, a slow process. It tends to be slower and more arduous in those countries which have reasonably large and relatively long-established university systems, as is the case in Latin America, India.

The reform of R and D and STS institutions

67. But even if reforms in the education system are carried through, there will remain the problem of the capacity of existing institutions to increase their rate of performance of R and D and STS work. In other words, manpower availability is not the only constraint. In the short run, at least, there are organizational problems whose precise impact it is hard to measure, but whose effect might be considerable:

(*a*) The rate of execution of R and D in the higher education sector is very limited because of heavy teaching loads, multiple employment of academics, administrative pressures and so on. These difficulties have run so deep that many academic scientists in the developing countries virtually stop research activities and often lose contact with developments in their disciplines. Part of the problem would be solved by making sure that a relatively high proportion of new research manpower goes into the universities. But the deadweight of established professorial staff would remain, who would probably find it very difficult to go back to research work after years away from it.

(*b*) The government sector accounts for most remaining scientific and technological activities in developing countries. Here there are some serious organizational disorders arising mainly from the fact that scientific and technical workers are under civil service organization, which is often antithetical to the conditions for doing scientific work. In particular, the growth and co-ordination of R and D and STS activities are complicated by inter- and intra-ministerial rivalries. Once again reform is a slow process.

68. Thus institutional reform is necessary not only to increase the supply of scientific workers, but also to create the capacity to "absorb" them and to provide them with conditions for getting scientific and technical knowledge applied. Both types of reform are slow moving in general.

69. In short, increased R and D and STS expenditure would be folly if there were no reform of the institutions for carrying out these activities. The organizational problems in these institutes and services have to be solved; otherwise, the additional financial resources devoted to them will largely be wasted. It is relatively easy to increase expenditure on science and technology, but there is a grave danger that the increased expenditure will leak away in a kind of "scientific conspicuous consumption".

Institutional arrangements for the application of technologies

70. The fundamental problems of getting technologies applied very frequently lie in prevailing forms of economic organization. At the same time, however, successful application depends on an adequate system of institutions, like extension services, concerned with encouraging the application of technology and on adequate coupling between these institutions and all other STS activities. There must be firm connexions between every link in the technology application chain. Thus:

(*a*) Technologists, able to understand the contributions of fundamental research, but familiar with industrial needs and problems, should provide liaison between fundamental and applied research functions;

(*b*) As close a contact as possible should be encouraged between fundamental research scientists, technologists, applied scientists, extension officers and potential industrial and agricultural users;

(*e*) Liaison and extension officers are also needed to help potential industrial and agricultural users to recognize their technical needs and problems, and to relate applied scientific research to these needs and problems.

71. Whilst all these service activities are absolutely necessary, their tasks will be exceedingly difficult in social circumstances where various systems of authority and tradition guide individual behaviour and decisions. The business of getting technology applied is much easier where people are able to consider problems of production — and other problems — in a rational and scientific way. There is, therefore, a strong case for large-scale programmes to bring an awareness of science and the scientific method to the community as a whole, and to encourage the participation of the community in the actual process of development of new modes of production.

Quantitative expenditure targets

72. At present the developing countries spend on the average about 0.2 per cent on their GNP on R and D proper. This is the best available estimate; it is probably on the high side.

73. We propose that in the aggregate, the developing countries should aim to reach R and D expenditure levels of 0.5 per cent of GNP by the end of the Decade. Given the assumption of an aggregate GNP growth rate of 6 per cent *per annum*, this would imply an average annual increase of just over 15 per cent in real expenditures on R and D over the Decade.

74. We have expressed the target in terms of R and D expenditure, because the statistical data are best for these activities. It is, however, essential to bear in mind that there should be a similar — or possibly even a greater — increase in STS in general and in all other activities listed in section I. Expanding R and D by itself will not be economically useful.

75. The target probably represents the maximum feasible growth of R and D expenditure when manpower constraints are taken into account. In an initial phase whilst the present underfinancing of STS is corrected and when new institutes are being built, expenditures may rise more rapidly; but, on the average over the Decade, they will be limited by the availability of R and D manpower.

76. At the same time, in setting this target, we wish to underline the fact that we presuppose that the various reforms of science and technology institutions in the developing countries discussed above will be undertaken. Unless they are, the expansion of expenditure will be impossible. Or, if there is an increase in expenditure, it will merely exacerbate existing problems and be a waste of scarce resources.

77. The target is an aggregate one for all developing countries; it cannot be applied to any specific country without qualification. Some countries have already surpassed this level of R and D expenditure; others, like India, are closer to it than the average. Obviously the target will have to be disaggregated in order to make sense in operational terms.

78. An examination of the operational implications of the target will certainly reveal problems of "sub-threshold" effort; that is to say, in small poor countries the feasible expansion of science and technology activations will result in a situation where the concentration of science and technology activities will be very small, probably far too small to be productive. This question has major implications for implementation. First, it points up the importance of a carefully planned orientation of effort in the developing countries. Secondly, it suggests that regional co-operation between some groups of developing countries (particularly in Africa) is a *sine qua non* for productive scientific and technological effort. In spite of the acute problems to which regional co-operation gives rise, it is essential in many cases.

79. Clearly, in order to attain an aggregative target of this magnitude, the developing countries will have to initiate considerable changes of a generally difficult kind. But even the major effort that this implies will only have a limited effect on the international division of labour in science. In terms of R and D expenditure, the target we have set would mean that at the end of a decade, the developing countries might account for some 4 or 5 per cent of world expenditures outside the centrally planned economies.

80. In other words, a great many of the problems associated with the present concentration of world scientific effort would remain. There would still be forces making for " internal " and " external " " brain drains "; and there would still be a preponderant scientific effort directed to economic objectives in the advanced countries which have negative or " backwash " effects on the developing countries. In all likelihood, the various effects of the international division of labour would in fact vitiate much of the effort the developing countries might make themselves, and could simply lead to a waste of valuable resources in those countries.

81. Thus, whilst increased domestic effort of the developing countries is essential if scientific and technological potentials are to be exploited there, a major effort by the advanced countries is no less necessary.

THE REORIENTATION OF SCIENTIFIC AND TECHNOLOGICAL ACTIVITIES IN THE ADVANCED COUNTRIES

82. The individual efforts of the developing countries will come to very little unless there is a parallel effort in the advanced countries, both to provide direct support to the build-up of science in the developing countries and to reallocate their own scientific resources towards new objectives related to the problems of the developing countries. Advanced country assistance may take multilateral or bilateral forms.

Direct assistance to the build-up of indigenous scientific and technological capability in the developing countries

83. A part of the advanced country contribution to the international effort will be the provision of direct assistance. This should take the form of: transfer of physical resources to meet the science and technology requirements of the developing countries, and technical assistance programmes, namely sending experts abroad to advise on science and technology build-up in developing countries and to do R and D work there, and training scientists from developing countries in advanced countries.

84. The physical resources transferred to the developing countries must meet the following objectives:

(*a*) They must help to overcome domestic financial constraints which, quite apart from manpower and organizational bottlenecks, might jeopardize the attainment of developing countries' expenditure targets. In other words, the calls on investible resources might be so considerable that resources available for investment in science and technology fall short of planned investments and a " science and technology savings-investment gap " might eventuate. Thus, resources transfers might be necessary to meet local requirements, for example, on setting up new institutes;

(*b*) They must help to overcome balance-of-payments constraints on the import of expensive items of equipment from the advanced countries. Again, the calls on national foreign exchange resources for other purposes may constrain the possibility of importing equipment. This might itself restrict the possibility of attaining expenditure targets or, more probably, result in a change in orientation of effort from planned orientations;

(*c*) They should enable the developing countries to contract for R and D and other science and technology services to be performed for them by institutes and companies in the advanced countries. In this way, demands for scientific and technological inputs arising in the developing countries themselves would exert some influence on the orientation of international scientific effort.

85. The technical assistance programmes which will be required as part of the over-all effort have to include all those activities designed to help the developing countries meet the conditions which are necessary for the accelerated and planned build-up of indigenous science and technology. Technical assistance activities would then cover the following: advisory work and training on university reform; advisory work and training in " science policy " and in science organization; advisory work on the organization of R and D and science and technology institutions in general, and training of research workers and other scientific and technical workers in the educational institutes of the advanced countries.

86. In our view, generous advanced country technical assistance to the science and technology activities of the developing countries is likely to be absolutely necessary if the developing countries are to accomplish the organizational reforms and the setting up of new policy-making institutions which are essential for the orderly attainment of the R and D expenditure target.

87. Technical assistance in the form of training of scientific personnel from the developing countries involves some particular issues which we deem it necessary to spell out in more detail.

88. The training of highly qualified scientists and engineers is at once the most useful and, at the same time, dangerous activity the advanced countries could undertake. It is useful because the manpower constraint is likely to be crucial to the development of science and technology in the developing countries. It is dangerous because it may simply add to the outflow of trained personnel.

89. This danger is so pervasive that we are forced to set what we regard as an essential pre-condition. Training programmes will only make sense in a changed world scientific context, where:

(*a*) The advanced countries themselves are developing major science and technology programmes for the developing countries and, therefore, have re-designed their scientific education systems so that they provide an education that is relevant to the problems of the developing countries;

(*b*) The concept of " science for development " is fully recognized by the scientific community and properly built into their incentive structures; and

(*c*) The scientific institutions of the developing countries are themselves reformed and properly motivated so that the newly trained scientists have something worth going back to.

In any other context — for instance, within the present world context — the increased training of scientific manpower in the advanced countries may simply undermine the efforts of the developing countries to build scientific institutions. The technical assistance aspect of advanced country efforts thus also brings us face to face with the more fundamental necessity for a reorientation of international scientific effort.

A quantitative target for direct assistance to science and technology in the developing countries

90. There is no better theoretical basis for calculating this target than for the others. We have, once again, attempted to arrive at a feasible scale of activity by looking at the discernible constraints. On this basis, we have concluded that the advanced countries might be called upon to transfer resources equivalent to 0.05 per cent of their GNP to the developing countries for direct support of science and technology.

91. Assuming that the general aid target of 1.0 per cent of GNP is reached, this would represent 5 per cent of total aid in the target year. If all official aid amounted to say 75 per cent of the total aid flow, it would represent some 7 per cent of official aid flow and would absorb about 12 per cent of the increase in official aid between now and the target year. Given the special importance of the other components of official aid, this would seem to us to be the maximum feasible science and technological component in aid, although our judgement here is based on guesswork.

The reorientation of advanced country scientific and technological efforts

92. The reorientation of advanced country scientific and technological activities plays two essential roles in the programme as we conceive it. First, this reorientation is necessary in order to overcome the influence of present patterns of effort on such problems as the " internal " and " external " outflow of trained personnel. The build-up of indigenous science in the developing countries will be undermined unless this can be achieved. Secondly, the reorientation is necessary if the composition of the stock of knowledge is to be significantly changed and if some of the negative effects of advanced country science and technology are to be overcome. Particularly in the light of these " backwash effects ", we do not regard the advanced country efforts to

reorient their scientific activities as part of aid programmes properly so-called. They should be viewed rather as a compensatory attempt to correct the irrationalities that arise from the present international division of labour in scientific work, and particularly for the negative consequences which scientific and technological advance has had on the developing countries.

93. The main objectives of the expanded programme must be to fill the gaps in knowledge relevant to the environment in the developing countries. These gaps have resulted from the past orientation of world science to the political and economic objectives of the advanced countries.

94. The priority areas selected by the Advisory Committee show just how serious these gaps are; they also provide the main immediate objectives for the expanded R and D and STS programmes. We presume, therefore, that a large proportion of the advanced country resources which will be devoted to scientific and technical problems of the developing countries will be concentrated on the areas for " concerted attack " designated by the Advisory Committee and discussed in detail in the World Plan of Action for the Application of Science and Technology to Development.

95. In addition, the last two decades have witnessed a great emergence of new technologies which promise possibilities of fruitful application to the developing countries, somewhat parallel to the sharp gains in the fields of medicine and public health brought about by the discovery of antibiotics and DDT in the prior years. Advances in space technology have opened up possibilities with positive implications for agriculture, resource surveys and education. Advances in computer technology promise economy in skilled manpower and management resources as well as gains in quality control. Nuclear energy offers to the arid areas of the world desalination and large-scale agro-industrial complexes. Transistors and miniature circuits have made several industries less capital-intensive and, therefore, easier for establishment and successful operation in the developing countries. The exploitation of the resources of the sea-bed is receiving increasing attention. A large volume of research is being devoted to discovering more practical means for the control of human fertility. It is not yet certain that these discoveries will mean a technological " breakthrough " in the development process of the developing countries. Considerable technical and economic research is warranted in both the developing and advanced countries specifically directed to their meaning for, and application to, the problems of the developing countries.

96. In essence, what is needed is an attempt to change the composition of the stock of knowledge so that it is relevant to the developing countries. In particular, this means a redirection of resources of science and technology towards the products, raw materials, and methods and scales of production of particular importance to the developing countries. There are really two aspects to this problem: one is to change the spectrum of technologies now being developed and made available to developing countries, so as to add to that end of the spectrum where input requirements are closer to the pattern of resource endowments in the developing countries. The second aspect is to enable developing countries to make better choices, selections and adaptations in the existing spectrum, largely again with a view to enabling them to find more appropriate mixes which satisfy their desperate need for reducing unemployment, and for spreading the participation and benefits of development more widely among their populations.

97. At the present time, it would not be far wrong to say that everything conspires to prevent the developing countries from selecting, even from the existing spectrum, the capital-saving and employment-generating technologies which may be optimal. The consulting firms which they employ on preparing projects, making feasibility studies, drawing up specifications and contract provisions, examining tenders etc. are all steeped in the technological outlook and traditions of the richer countries. The same is true also where local officials or local technicians are available and employed.

98. The advocacy of greater application of labour-intensive technology as an urgent need in developing countries, both in the sense of a better selection from the existing spectrum and the development of a better spectrum, must not be taken to an extreme. The fundamental requirement is economic efficiency in terms of the resource endowment of the developing countries. We believe, however, that the scope for the employment of efficient labour-intensive technologies is considerably greater than at present.

99. At the same time, some action is required on the specific adverse consequences which the concentration on synthetic substitutes has had for the developing countries. A purely negative approach to this question would do more harm than good. Attempts to prohibit or "police" research on synthetics would almost certainly be both backward-looking and ineffective. The new materials have properties and uses which are of immense benefit for the whole world economy, and potential applications of value to the developing countries. The primary aim of policy should, therefore, be the positive and constructive goal of building up the scientific capacity of the developing countries so that, on the one hand, they are able to strengthen the competitive position of natural materials through advanced research and, on the other hand, are able to develop a new range of applications for synthetics, which are principally of interest to the developing economies. Many of these have in fact the resource endowments which would enable them to become centres of the petrochemical industry, and of production of the synthetics. A policy of restricting the developing economies exclusively to natural materials would be suicidal in the long run. They must themselves have the scientific and technological capacity to participate in the synthetic revolution, whilst simultaneously exploiting their natural resource endowment.

A quantitative target for the reallocation of the scientific and technical resources of the advanced countries

100. The reallocation of advanced country science and technology towards the problems of the developing countries should be treated as an essential means of overcoming the adverse consequences of the present international division of labour in science and technology; for example, the outflow of trained personnel and the development of synthetic substitutes and methods for economizing on the use of primary materials. Attempts have been made to quantify the effects of these factors. We believe that the sum total of what is being proposed here in terms of reallocation of effort will do no more than compensate the less developed countries for the combined effects of these adverse impacts.

101. In examining this question against the necessity to get a substantial change in the orientation of world science and technology, and to overcome the consequences of the existing international division of labour in science, one could be strongly inclined to propose major changes in the pattern of R and D spending in the advanced countries. On the other hand, we must recognize that there would be considerable problems in getting such major changes, both on technical grounds and because of the changes in political priorities which they imply.

102. In the light of these considerations, we are led to propose that the advanced countries should devote some 5 per cent of their total R and D expenditure in the target year to specific problems of the developing countries. Assuming that advanced countries' GERD/GNP ratios reach 2.5 per cent during the decade, this would represent about 0.13 per cent of their GNP on the average. In the context of a considerably expanding total R and D effort in the advanced countries, this target seems well within the bounds of realistic expectation.

103. Taken together with the increased efforts of the developing countries themselves and direct aid flows to support these efforts, the target would imply a modest reorientation of world scientific effort. The total expenditure on R and D for and by the developing countries would be roughly equivalent to present expenditures on space research. This effort would, however, be devoted to a relatively large number of specific objectives.

104. We reiterate that the feasible target for reorientation of advanced country effort seems to be well below what would be desirable. In particular, if the coming decade sees a slowdown in the growth of expenditure on military science, there would be a strong argument for a reorientation of effort greater than we have proposed.

Some implications for the United Nations

105. A greater allocation of resources to STS in the developing countries, or to problems of specific interest to less developed countries, could be done either bilaterally or multilaterally. There are certainly considerable advantages in deploying part of the new resources multilaterally, including activities under the auspices of the United Nations. This also applies to the proposal for establishing technology transfer

banks. Further study may indicate that an international bank for the transfer of technology within the United Nations system is the best solution. Within the next development decade, the resources of the United Nations system, both in the International Bank and in the United Nations Development Programme, are expected to increase considerably. Such increases are already in sight for the next few years. Expanded activities by the United Nations to intensify the application of science and technology in the developing countries should represent a high priority claim on these additional resources. Changes in rules and ways of operation, and possibly also in organization would be required. No detailed proposals for such changes are made in this part of the World Plan of Action, but it is likely that the present rules of operating only on strict national country requests, and also the rule of not supporting activities carried out within the developed countries, will have to be revised.

"COUPLING" — THE PROBLEM OF ACCESS TO WORLD SCIENCE AND TECHNOLOGY

106. The proposals in the preceding sections cover efforts required from both the advanced and the developing countries. The success of the programmes as a whole depends on the proper linking of these various efforts, and also on specific action to solve problems of access to foreign technology.

The "coupling" of scientific activities between advanced and developing countries

107. The importance of "coupling" in the science and technology systems has major implications for the manner in which scientific and technological activities are organized in the industrialized countries to aid the developing countries. However well-intentioned and however generously financed, such efforts are likely to be largely ineffective unless there is direct personal contact with scientists and technologists in the developing countries themselves. Wherever possible, part or all of the scientific work should actually be carried out in the developing countries. When this is not feasible, generous provision for travel and first-hand acquaintance with the real problems are absolutely essential. Even where these conditions are satisfied, coupling and information flows will remain difficult problems. Great ingenuity and flexibility will be necessary to overcome the communication difficulties, which are much greater in international transfer than in purely internal transfer. Any international or bilateral scheme should have scope for a wealth of independent activities and local variations.

108. As we have shown, the establishment of a scientific capacity in the developing countries involves building up a range of different scientific and technological organizations. In addition to research laboratories, these will include resource survey organizations, testing facilities, scientific information services and so on. These institutions also can benefit from effective coupling with similar organizations in the industrialized countries.

109. The leading industrial, university and government laboratories all have an important role to play in carrying out R and D for the developing countries, but it will require a major impulse from central Governments and strong financial support to bring about reorientation on the scale required. Extra-mural grants and contracts on a generous scale should be available to scientific organizations which propose to undertake projects of direct relevance and benefit to the developing countries. Major programmes should be initiated in all the industrialized countries and not just in one or two. There are already quite a number of universities running projects on problems of the developing countries, and this should become the norm in every university. The more far-sighted science-based industrial corporations in Europe, north America and Japan have already started programmes in this field and recognize the urgency of the problem. It should become the normal thing for industrial R and D laboratories to have "Third World" contracts and projects. All these various efforts will have to be linked in with the scientific work going on in the developing countries themselves.

110. In all this, however, a necessary condition is that scientific work on problems of the developing countries must achieve the same legitimacy in the eyes of the scientific community as, say, work on atomic programmes or the space programme

has today. This will, no doubt, be achieved in part if "development science" is sanctioned by sufficiently large budgetary allocations. But this is only part of the story. A further major factor is that scientists will make a greater contribution to development needs if they know what objectives are relevant both to their own work and to development requirements; and if these objectives are relevant to the criteria for judging scientific work.

111. This again involves new links between science in advanced and developing countries, particularly in the education of scientific workers. At present, science education trains the young scientist in the methodology of research and introduces him to the body of knowledge in his area of specialization. It is granted that research training should focus on the methodology of fundamental research. Most science education, however, stops at this point. There is a strong case for including in the education of scientists, some training in the analysis of social and economic problems, and in methods of applying scientific expertise to their solution. Science education which stops at fundamental physical science training is not enough; a considerable contribution can be made through multidisciplinary team teaching, where course work is centred around national social issues, for example, the urbanization crisis, agricultural inefficiency, problems of small manufacturing industries etc. The purpose would be to encourage students to define the social issues in terms meaningful to their own experience, and then apply their own scientific research competence to these issues.

112. At the same time, efforts will be needed to change the reward and incentive structure for scientists. Career success for a scientist is presently evaluated largely in terms of publications in professional journals, where heavy emphasis is placed on fundamental research contributions. The United Nations could contribute towards a new motivation of the scientific community by sponsoring publication media of sufficiently high status to be acceptable professionally, yet having a heavy emphasis on development problems.

The specific problem of access to world technology

113. To enable the developing countries to make better use of available technologies, the impediments to the transfer of technology must be reduced. In part, of course, these impediments result from the limited capacity to absorb technology. But, there are also problems of access to technology which have to be attacked separately. The problem is to give developing countries access to a wider range of technologies for the development of domestic production. In order to do so, it is essential to break out of the present situation in the world "market" for technology where, by and large, the companies which own technology are only willing to have it exploited in the developing countries if they are able to invest directly.

114. It is clear that if the developing countries are to make greater use of existing technology, then some means must be found for facilitating its transfer from these enterprises which possess it to those who wish to use it. The success of any venture to promote the transfer of technologies to developing countries depends on the concurrence of enterprises in the advanced countries. The problem is to find a mechanism which will meet the interests of these enterprises as well as the interests of developing countries. Such a mechanism was suggested at the second session of UNCTAD held at New Delhi. In principle, we support the idea of an international technology transfer bank or agency similar to that proposed at New Delhi. This institution would, on the one hand, attempt to cover the risks faced by the companies possessing technologies and, on the other, it would help to reduce foreign exchange costs of technology purchases. The bank or agency might go further: it might finance research on new technologies designed to meet the specifications of the developing countries.

ECONOMIC REORGANIZATION OF THE DEVELOPING COUNTRIES

115. Whilst these interrelated objectives which deal specifically with science and technology are the main elements in the strategy for the application of science

and technology to development, they will make no sense at all unless the conditions for the application of new technologies are created in the developing countries. This may seem trite but, since it is questionable whether the required conditions exist in the developing countries, the point has to be spelled out.

116. The essential requirements in the developing countries are:

(*a*) There has to be a " perceived need " for inputs of science and technology to production; and

(*b*) It has to be possible to mobilize complementary inputs and to create institutional conditions to get technologies applied.

117. First, there is the question of what is a " perceived need ". The inference of the preceding analysis is that the " need " for science and technology in the developing countries is unlikely to take the form of a commercial demand coming from individual producers. The way production is organized is all against this, and even if it were reorganized, it would take some time before such demands eventuated. This means that the " need " for science and technology will be mainly a function of whether and how far planning bodies (and other organizations responsible for development policy) see a role for science and technology in the development effort. This has two important consequences. First, it implies that there has to be a change in the outlook of the groups responsible for development policies and their implementation. Because of their training, planners and others find it difficult to conceive the role of science and technology in development. Setting up national science councils and the like may help to some extent, but the problem of changing conceptions in development policy usually remains. And, there are still very considerable methodological problems about how to relate science and technology policies to development policies, which complicate the whole process. Secondly, the " need " for science and technology may only be perceived if one takes a long-term, perspective view of development because many R and D projects take a long time to give results. This means that the " present need " for R and D will only really be " perceived " if perspective planning methods are used in much greater detail than is normally done.

118. The second question is about creating the conditions for the application of science and technology to production. At one level, this involves planning for the various factor inputs which are needed to operate new technologies. These may be capital inputs, or skilled technicians, or new kinds of managers, or maintenance workers etc.

119. But, more fundamentally, the problem is one of reorganization in the economy. It may, for example, be pointless to undertake programmes on new seeds or new agricultural outputs unless there is land reform or reform of tenure systems. Again, the availability of labour-intensive technologies will not in itself result in their use, particularly if relative factor prices are unsuitable. The examples could be multiplied. The point is that the rationale for specific science and technology programmes is directly dependent on the seriousness and success of general development policies. Such reorganization is a slow process and political constraints may make it difficult to achieve.

120. The World Plan of Action in science and technology, further, cannot fail to take account of another important factor which itself lies outside the field of science and technology. This is the trade factor. It should be possible for the developing countries to utilize their comparative advantage of abundant labour and lower wage rates by specializing on the production for export of labour-intensive products. Greater access by the developing countries to the markets of the richer countries in respect of labour-intensive products would be no panacea: it may well be that much of the apparent advantage of lower wages would be cancelled out by lower productivity. Effective labour cost might not really be lower in spite of lower wage rates. Hence, freer access by developing countries to markets would have to go hand in hand with rising productivity of labour including intensive technical assistance towards this end. However, given combined progress in raising productivity and giving freer access, a consistent and concessionary trade policy towards developing countries should be considered as an essential twin pillar of a plan for the wider application of modern technology to developing countries.

121. The implementation of the policies we have proposed will only make sense and only be justified to the extent that the required reorganizations of the national and international economies are achieved.

122. We cannot fail to note that together the quantitative targets would imply a vast expansion of science and technology effort for the developing countries over the Decade. They would imply, over a slightly longer term, a massive increase in new technologies. When we remember that, at present, there is every evidence that the developing countries are unable to absorb available technologies and to exploit scientific and technical potentials, it is clear that the expanded science and technology programme implies the necessity of major changes in economic organization. This point cannot be too strongly emphasized. Science and technology may be necessary for development; but simultaneously, development efforts are necessary if science and technology are to be used.