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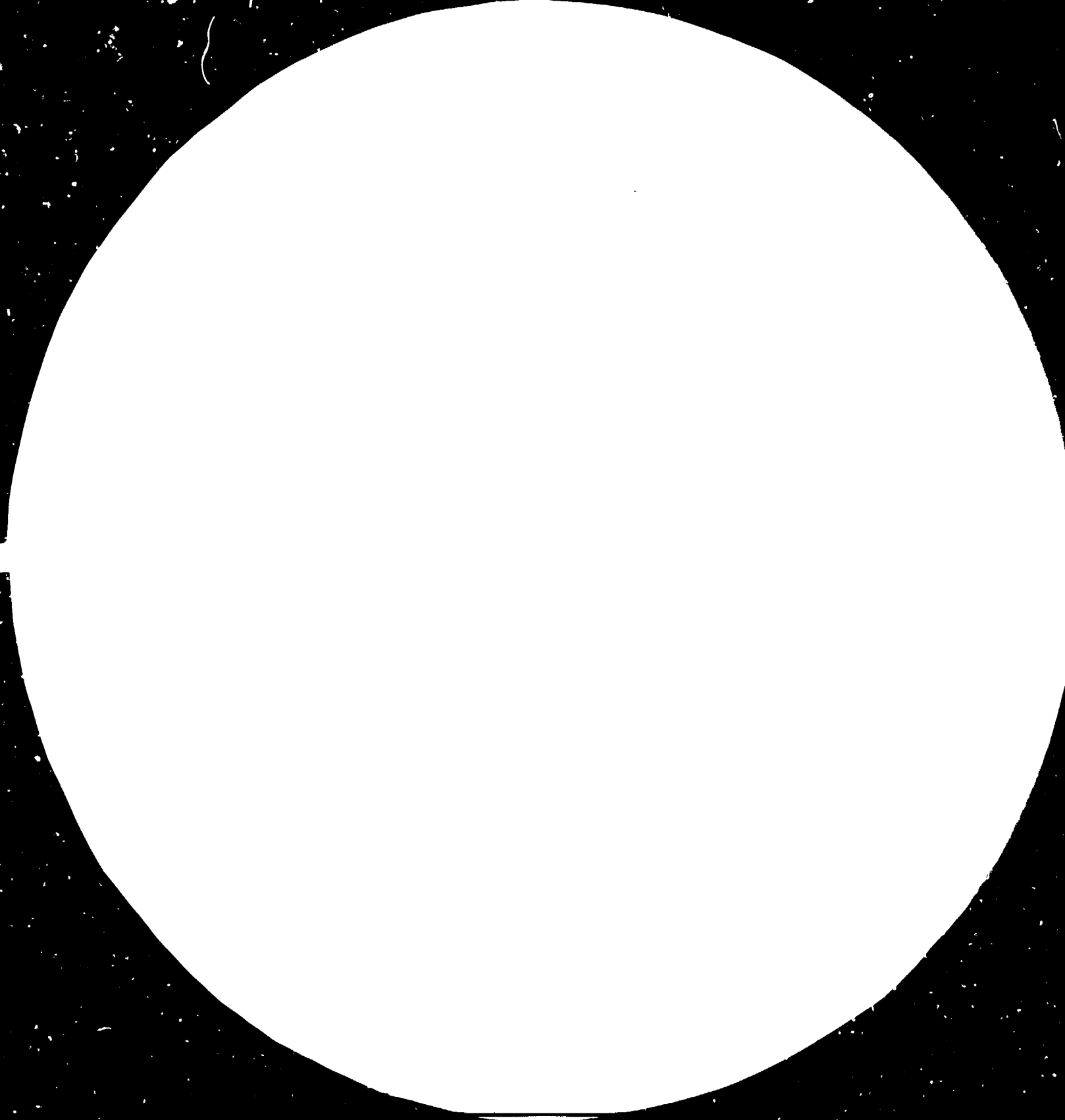

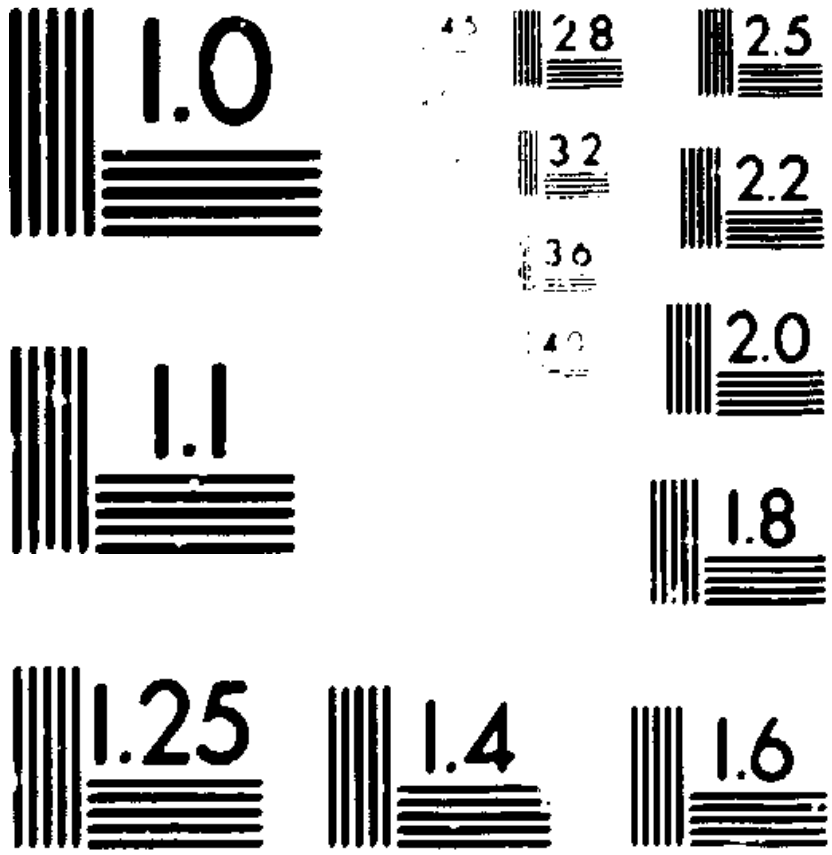

Item 5(b) of the provisional agenda

INTERNATIONAL CO-OPERATION, RELEVANT NATIONAL ACTIONS INCLUDING INDUSTRIAL POLICIES, AND UNIDO'S CONTRIBUTION IN CRITICAL AREAS OF INDUSTRIAL DEVELOPMENT 1985-2000:

Strengthening of scientific and technological capacities for industrial development in developing countries

Background paper prepared by the UNIDO secretariat

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CONTENTS

INTRODUCTION

1. The Second General Conference of UNIDO highlighted, inter alia, several measures for international co-operation in the transfer of technology and the appropriate selection of technology. 1/ The Third General Conference, following closely in the wake of the United Nations Conference on Science and Technology for Development, accorded high priority to technology and in section III of its Plan of Action 2/ made a series of important recommendations on industrial technology. The Caracas Plan of Action, adopted by the High-Level Conference on Economic Co-operation among Developing Countries, held at Caracas from 13 to 19 May 1981 (A/36/333, annex, paras. 7-26), outlined several measures of technological co-operation among developing countries that could contribute to their collective technological self-reliance. Although these events reflect the growing perception on the part of developing countries of the critical role of science and technology in their industrialization, the strengthening of their scientific and technological capabilities remains a challenging task in their efforts to achieve the Lima target of industrialization.

2. It is now a recognized fact that the gap between developed and developing countries in technological development makes them unequal partners in international economic relations; that the costs and conditions of the transfer of technology could be, and often are, onerous; that an inappropriate choice of technology is not only wasteful but could distort the pattern of industrial, economic and social development; that strengthening technological capabilities is a prerequisite both for the acquisition and application of imported technology and the development of endogenous technology; and that the way technology is applied critically affects the development process. The extent to which these perceptions have been translated into effective action has varied from one developing country to another. A measure of strengthened technological capability in developing countries can no doubt be inferred (though superficially, with wide variations among countries) from the increase in their industrial production, its growing share in their gross national product (GNP) and a greater share of capital goods in their imports. In some cases, clearer indications of strengthened capabilities are available in terms of local production of capital goods, an increase in the indigenous content of manufactures, and exports of manufactures, capital goods and technology. In short, technological capability and its depth are closely related to the rate and the pattern of industrial development.

3. Several developing countries have also augmented their scientific and technological manpower. But in most cases they have not yet reached the point at which dynamism in the industrial structure becomes self-generating and the benefits of technology are made available to the vast masses of population. A large number of the developing countries are still in the early stages of technological development and are far from achieving any measure of technological self-reliance. Admittedly, the developing countries are trying to compress into a relatively short period what the now developed countries achieved over a much longer period. Even so, the present situation calls for purposeful review and effective action at the national and international levels.

4. The emergence of technological advances that will alter the rate and pattern of industrial production in the present and coming decades and indeed change the very content of technological capabilities has lent a measure of urgency to such review and action. For here are the beginnings of yet another dimension of industrial and technological gaps and new patterns of dependence. At the same time the potentialities exist for developing countries to "leap-frog" some of the gaps. 3/ Industrial technology for the 1980s is then not a matter of a routine decennial review but one of strategic significance. The present international economic situation is not a ground for postponing consideration of the issue, for recovery could well spur the further development and application of technological advances.

5. Industrial technology for the 1980s will have to be considered in close relation to several other issues before the Conference, in particular industrial policy and restructuring, energy, and human resource development. In view of the close and dynamic interrelations between industry and technology, they cannot be considered in compartments within the future industrial, technological, economic and social development of developing countries. Even more than before, technology will, in the medium- and long-term context, be a key factor in future development. The present situation underlines the need for a suitable framework for national action to strengthen technological capabilities and for an expansion of the frontiers of international co-operation and enhancement of its content.

6. Throughout the present report, the word "capability" is used, rather than "capacity", to stress the human resource aspect of technological development. The report focuses upon technological capability, scientific capability being discussed where appropriate.

I. PROGRESS AND CONSTRAINTS

7. A national scientific and technological capability for industrial development embraces everything that is required for the successive steps of building up and managing industrial capacity. 4/ A review of the progress made by developing countries in selecting, acquiring, adapting, absorbing and developing technology was therefore included in the UNIDO secretariat's documentation for the United Nations Conference on Science and Technology for Development, subsequently submitted to the Third General Conference (A/CONF.81/BP/UNIDO) and for the Industrial Development Board (IDB) at its sixteenth session (ID/B/281). A review 5/ of the progress achieved was also undertaken in connection with the monitoring of the implementation by developing countries of the Lima Declaration and Plan of Action. Hence, it is proposed only to highlight the contours of national progress and constraints in certain key areas, bearing in mind the considerable variation in levels of technological development among developing countries.

A. Selection and acquisition of technology

8. Most developing countries show a considerable awareness of the importance of technology for development, but little attention is paid to the selection of technology at the micro and macro levels. At the micro or enterprise level, the non-availability of processed information and the lack of evaluating capacity make selection difficult. Moreover, Governments intervene relatively rarely through industrial or import policies or decisions on major projects. Selection from among all available options is further hampered by such factors as foreign investment and the availability of credit facilities from one or other country or supplier of equipment. The absence or non-association of indigenous consultancy services and multidisciplinary teams trained in technology evaluation creates a major bottleneck. The redesign of existing industrial and technological information centres and the promotion of consultancy capabilities should therefore be viewed not so much as general elements of infrastructure but rather as key factors in a better selection of technology for the country. The present status of technology selection and the difficulties inherent in the process would argue for recognition of its importance in a wide range of government policies and a conscious exercise of selection, at least in major and strategic projects.

9. At the macro level, an assessment or at least awareness of the impact of specific technologies on society and their contribution to particular development needs is essential and needs to be reflected in conscious decisions on the "technology mix" to be adopted. The absence of an overall approach to the selection of technology has had implications for the pattern of industrialization and employment generation in developing countries (see paragraphs 21 and 22).

10. As regards the acquisition of technology, the need to strengthen the negotiating capabilities of entrepreneurs and government officials in developing countries has been recognized and several countries have benefited from training courses, manuals etc. Costs and conditions of technology contracts continue, however, to be of particular concern to developing countries. Even though in many cases almost all the technology is imported from abroad, control over the acquisition of technology is evident in only about 20 per cent of the developing countries (a much greater percentage in terms of value of production, since many of them are more advanced developing countries) and that, too, to varying degrees. Technology registries of those countries have also been exchanging information and co-operating among themselves under the aegis of the UNIDO Technological Information Exchange System (TIES). A recent survey showed that nine countries have legislation governing the regulation of imported technology, three have issued guidelines, eight have instituted administrative controls and another eight are planning to introduce them. Although most of them are the more advanced developing countries, several less advanced ones have decided in recent years to adopt regulatory measures. The point to note, however, is that a large number of countries have so far failed to adopt any regulatory measures and even the countries that have done so do not all monitor imports of equipment (constituting a transfer of embodied technology), nor do they follow up the absorption and further development of the imported technology. While the regulatory institutions have helped to limit the size of payments for transfer

of technology and to obviate restrictive clauses in technology contracts, the regulation of imported technology appears to be viewed as an operation by itself and not as part of a larger effort to absorb and further adapt or develop imported technology in the context of long-term industrial plans for specific sectors. In some cases, repetitive imports of the same technology have continued, with no horizontal transfers within the country.

11. Some of the countries that have not adopted regulatory measures have not been aware of the value of regulation and others have perhaps made a conscious decision not to have such regulation at present. Among the latter are countries that do not regard themselves as having reached a stage of development at which regulation may be considered necessary. Yet others have to contend with financial and managerial resource constraints, and they believe the climate for foreign investment would be upset by the regulation of technology imports. Financial and manpower constraints thus lead to technological constraints. Some countries perhaps consider that at a given moment it is more important for them to set up industries than to build up technological capabilities. Generally speaking, the more industrially advanced developing countries have found some regulation and monitoring of imported technology both necessary and useful. In the long-term, all developing countries may find it useful to watch the inflow of technologies and their impact, though the need for and the extent of regulation may vary according to prevailing conditions and policies in the country concerned.

B. Development of endogenous technology

12. The developing countries are fully aware of the importance of the development of endogenous technology and most have established single-purpose and multi-purpose research institutions of various types. 6/ Institutions for scientific education and basic research have also been established. Universities in several developing countries have started to play a role in the development of endogenous technology. Some countries are also planning to establish science parks. The Governments of several developing countries are promoting endogenous technology through a variety of incentives such as tax concessions, liberalized licensing procedures, financial incentives and special funds to support endogenous creativity and innovation. In some countries, patent laws have been changed to eliminate restrictions on the development or use of technology. Generally speaking, most of the research and development is carried out in government-run institutes, although in a few developing countries it has been introduced at the enterprise or industry level. A few countries, too, insist on local research and development as a condition for the import of technology. Institutions for standardization, testing and quality control, which form part of the infrastructure for technology development, have also been established in a number of countries.

13. In spite of the foregoing efforts, the development and commercial use of technologies by developing countries has been limited. 7/ From a review carried out jointly by the United Nations Development Programme (UNDP) and UNIDO of a number of industrial research and service institutes 8/ it can be concluded that research and development institutions in developing countries have been at their most useful in long-term institution building and staff

development and less so in terms of their immediate relevance to the productive sector and national development. The reasons for this are varied and well-documented. They include financial and human resource constraints, operational shortcomings and poor contacts with the productive sector, whether for the commercialization of locally developed technology or for the improvement of imported technology. Moreover, the approach to industrial research is often not goal-oriented; it has limited relevance to major national problems and does very little to upgrade locally used technologies and solve the problems of the population in rural areas. There is little horizontal transfer of technology among commercial firms, mainly because of a fear of competition in a limited market.

14. A brief reference may also be made to the emergence of some developing countries as exporters of technology. Studies conducted by the UNIDO secretariat 9/ have revealed that developing countries export such technologies as construction and consultancy services and turnkey plants and also undertake direct foreign investment, certain countries showing a predominance in one field or another. While in some cases these technologies have been developed by local firms, in most cases they were originally imported and their lower cost or ease of adaptation made them attractive to the recipient country.

C. Human resources and technology 10/

15. Human beings are ultimately both the creators and beneficiaries of technology. Human resources are an important basis for comparative advantage in international trade and developing countries have recognized their importance for the development and application of technology. Though accurate or quantifiable estimates are not available, many developing countries have made considerable progress in creating an educated and skilled work force. In several semi-industrialized countries, the steady build-up of skills has resulted in a highly competent labour base, even by international standards; in many others, however, particularly in Africa, there is a shortage of skilled indigenous manpower for production operations. In several countries, educational facilities are lacking or weak and are academic rather than industry-oriented, unrelated to the absorptive capacity of the labour market or the national requirements. Different types of training programmes have been launched by a number of developing countries, 11/ though several relatively small developing countries lack the necessary scale of requirements to have full-fledged technical institutions. In a number of cases, the difficulties are compounded by a "brain drain". In general, more attention has been paid to hardware than to human resources in industrialization.

16. Technological manpower, however, is needed for other purposes besides production operations. A variety of skills are required at the government, enterprise and research institute levels, for the selection, acquisition, adaptation, absorption and development of technology. Some of the skills could be acquired through short-term training programmes, while others would require long-term training or education. Evidence of systematic attempts to build up a whole range of capabilities seems, however, to be lacking in most developing countries, particularly with respect to technological services.

17. Such services range from macro-level industrial planning to micro-level project identification, feasibility studies, plant specifications, detailed engineering designs, civil construction and machinery installation, and the commissioning, start-up and operation of plants. The most significant gap, even in fairly industrialized developing countries, is in basic and detailed engineering and design. This gap, with the consequent critical lack of infrastructure, makes the disaggregation of imported technology packages extremely difficult and creates an undue dependence on foreign design and engineering services. This dependence has a consequent impact on the pattern of investment for particular projects and on the requirements of capital goods and equipment, as well as on subsequent plant operations and management. 12/ In other developing countries, the gaps in consultancy services are even more marked and extend to almost the entire range of services indicated above. Nevertheless, there is now a considerable awareness of the need to establish consultancy services to disaggregate technology packages and to create local engineering and capital goods industries, which will contribute directly to the creation of technological capabilities.

D. Technological policies and plans

18. Replies from developing countries to a questionnaire sent out by the UNIDO secretariat in connection with the monitoring of the achievement of the Lima target were virtually unanimous regarding the need for explicit government action in the field of technology (see ID/B/295/Add.2 and Corr.1 and 2, para. 23). This was true even when the non-interventionist general strategies of economic development and the predominant role of private initiative were stressed. Nevertheless, explicit technological policies have been formulated and implemented in only a handful of developing countries, although a few more have adopted policies relating to the acquisition or development of technology.

19. Several countries have adopted explicit scientific and technological development plans and strategies (e.g. Brazil, Guatemala, Guyana, Mexico and India) or special chapters on technology within general development plans (e.g. Iraq, Nigeria, Romania and Thailand). Complementing or supplementing their technology plans, several countries have already set up an institutional framework dealing with technological development. The most typical institutions are the science and technology boards or councils organized in general as decentralized, high-level agencies with policy-making, co-ordinating and promotional powers (e.g. Brazil, Ecuador, Ethiopia, Guyana, India, Kenya, Malawi, Mexico, Nigeria, Pakistan, Panama, Peru, Singapore and Sudan). In a few cases, ministries of science and technology have been created, or special departments organized within other ministries to deal with technology policies.

20. To sum up, considerable progress has been registered in a number of developing countries, keeping in mind the fact that systematic efforts to develop technology date back on an average to not more than 15 years ago. In many cases, however, present efforts suffer from qualitative and quantitative deficiencies. Most developing countries have endeavoured to increase their scientific and technological manpower and many have devoted attention to

endogenous technological development, but in both cases they are encountering a number of problems. A relatively small number of countries have attempted to regulate imported technology (in spite of the fact that most countries are dependent on it) and even fewer have made any effort to adopt explicit technological policy and plans. Curiously enough, technological development and manpower call for financial resources and a long gestation period while policy formulation could be undertaken at little expense and with only short-term training - it does, however, require political action. Nevertheless, greater effectiveness in resource allocation, even for technological development and manpower, can only be secured through a technology policy.

21. The deficiencies noted here contribute in part to some major concerns from a development point of view, in the application and development of technology in developing countries. Two such interrelated concerns are the pattern of industrialization and employment generation. The pattern of technologies applied has skewed the pattern of industrialization in favour of urban concentrations and geographical enclaves, with little diffusion of industrial and technological development in the economy as a whole; and it has introduced products and patterns of consumption of lesser priority in the development process. It has also eliminated traditional technologies, sometimes because of the sheer volume of managerial, financial and marketing resources available to the larger firms. It has not contributed to the increase of productivity of the work force as a whole.

22. As regards employment generation, its growth has hardly been adequate in relation to the growth of the labour force. Further technological change is expected to accentuate this lag. Though it would be wrong to suppose that the severe unemployment problems in several developing countries will be solved by industrial technology alone, its contribution to employment generation has been constrained by governmental policies and entrepreneurial preferences in favour of capital-intensive technologies, lack of information on alternative technologies, inadequate capability for disaggregation of technology packages, and lack of infrastructural and financial support for dispersed industrial activities on a small scale. Technological alternatives do exist over a wide range of industries but have not been systematically put to use. 13/ It is also important to remember that industrialization promotes activities, and thereby employment, in the services sector and through linkages with other sectors.

23. In spite of the initiatives taken by several countries, ad hoc, uncoordinated or limited policies, rather than a total framework for national action, prevail in most developing countries. This fact may partially explain the deficiencies encountered.

24. Further efforts of developing countries to strengthen their scientific and technological capabilities call for a greater awareness of certain basic insights into the manner in which science and technology are applied to the productive sectors and therefore to development. It is sometimes believed that if a stock of technological manpower and infrastructure is created, technological and industrial development will take care of themselves. Dynamic interlinkages with the productive sector are as important in the context of scarce resources as the creation of a stock. It should also be remembered that technological elements are involved and decisions are made by

a variety of operators in the long chain of steps of macro and micro industrial development activities, and the strength of the chain is generally determined by the weakest (or missing) link. Decisions bearing on technology are based not only on technological content but on financial, management and organizational considerations. A major line of future action for Governments of developing countries would be to take economic, institutional and policy steps to ensure a dynamic interaction between technological and industrial development.

25. Furthermore, concepts and practices in the development and application of technology in developing countries have tended to imitate the process in developed countries but, in the absence of corresponding infrastructure and dynamic interlinkages, have not produced results. They have taken on an enclave character rather than benefiting the mass of the population

26. Technological development and application have been viewed as a linear process of "catching up". "Catching up" acquires a new meaning and poses a new challenge in the wake of the emergence of technological advances.

II. THE EMERGENCE OF TECHNOLOGICAL ADVANCES

27. In 1980, following the observations of the United Nations Conference on Science and Technology for Development, 3/ and as indicated in secretariat documentation for the Third General Conference of UNIDO (ID/CONF.4/7, para. 69), the secretariat embarked on a programme of technological advances with a view to identifying the potential and limitations of those advances for developing countries and making them more sensitive to the lines of action that might be needed. Studies, meetings and other promotional programmes were organized at the international, regional and national levels. 14/ The results of these activities were presented to the International Forum on Technological Advances and Development, held at Tbilisi, USSR, in April 1983 as a preparatory meeting for the present General Conference (see ID/WG.389/6).* The Forum examined in detail both overall policy issues and the implications and potential of six selected technological advances in the fields of genetic engineering and biotechnology, micro-electronics, materials, petrochemicals, energy from biomass and energy from solar photovoltaic cells. The results of the Forum show clearly that technological advances will perhaps be the single most important factor that developing countries may have to consider in relation to their industrial and technological development in the present and coming decades.

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* An expert group meeting was held in Moscow in December 1982 to prepare for the Forum (see ID/WG.384/16) and an expert workshop took place at Dubrovnik in May - June 1983 as a follow-up to some aspects of the Forum relating to institutional and structural responses of developing countries to technological advances (see ID/WG.401/7).

A. Impact of technological advances

28. In the 1980s and 1990s technological advances in a number of fields (genetic engineering, biotechnology and micro-electronics are outstanding examples) are expected to converge, leading to a significant measure of technological change. These advances are unique in their intensity and wide-ranging impact and lend themselves to rapid commercial application, given the infrastructure of the developed countries. Though estimates of the extent and time horizons of expected change may vary, the directions are clear. The advances are expected to alter the rate and pattern of industrial production in the present and coming decades and thus have particular relevance to the efforts of the developing countries to achieve the Lima target, to widen the technological gap between developed and developing countries and accentuate the technological dependence of the latter, and to change the life style of their people. With their impact on the international market for technology, the technological advances also add further dimensions to the issues of technological transfer and dependence.

29. In the industrial sector, where the first effects are likely to be felt, technological change will lead to the creation of new industries and the restructuring of existing ones. Changes in comparative advantage and the consequent impact on trade will further affect the existing and prospective industrialization of developing countries. Micro-electronics, for example, will have a major impact not only on the engineering industries but also on several other branches of industry, like printing and ready-made clothing, while offering possibilities of incremental improvement over a wide-range of industries. Biotechnology will have an impact on the chemical, pharmaceutical, food processing and energy industries. On a rough estimate something like 65 per cent of the industrial production of developing countries could be affected in one way or another by one or more of the technological advances. 15/ In addition, branches of industry could also be affected by internal technological changes and by variations in the costs and availability of energy and energy-related technologies. Thus, the further industrialization of developing countries will have to take place in a context of dynamic technological change, in which technological advances interact and, cumulatively, act on the industrial sectors. The impact of information technology on the service sectors is expected to be even greater.

30. The effect of technological advances on industry is among the first order of impacts, but the second order of impacts, affecting other sectors and development and society as a whole, may be even more important, encompassing skills, employment, work, work environment, leisure and family and social life. Control of the first order of impacts, on industry, therefore, becomes all the more necessary to control the second order.

31. The concept and content of the technological capabilities themselves are undergoing certain changes. In particular, thanks to the interaction between micro-electronics and telecommunication, changes are taking place in the way management decisions are made and communicated, the way production is organized, the way products and processes are designed and the way service functions are performed. In a competitive world, the dividing line between advanced and other countries may well be whether or not the new types of capabilities are available.

32. Conscious of the impact of new technologies and their implications for productivity and international competitiveness, practically all developed countries have initiated a series of policy measures to respond to technological change. 16/ The question for developing countries is whether they will be spectators in this process. Products, processes and techniques arising from technological advances are bound to have an impact on developing countries in the context of an interdependent world economy and their own technological dependence. The developing countries could either simply react to events and changes and keep rectifying their own position in a changing world or gain an insight into the new technologies and develop their capability to use them purposefully for their own requirements. It may be necessary to follow both paths, and in any case a timely and orderly response is of paramount importance. If the technological advances could be seen as new opportunities for revitalizing the development process and improving the quality of life, the challenge could be converted into an opportunity. The current concern regarding the rate and pattern of development makes it all the more necessary to find ways to apply the technological advances so as to benefit the development of all countries, and in particular the developing countries.

B. Potential of technological advances

33. As it happens, technological advances do contain features that could help the developing countries to "leap-frog" some of the hurdles inherent in their traditional approaches to industrialization, agriculture, health delivery, social services etc. Several common characteristics of the technological advances (particularly in micro-electronics and genetic engineering and biotechnology) should be noted. They are more and more based on science and on transdisciplinary basic research but are amenable to rapid translation into production processes. The technological development may be sophisticated but the applications are, in a number of cases, relatively simple. Several of the advances relate to a wide range of industries and could be applied in various sectors of the economy to improve productivity. Some of them are of particular relevance to national security. In general, they save or create energy and are environmentally sound, with low wastage, and amenable to decentralized production or application. The converging technologies are giving rise to a new stream of production processes, equipment, services and information systems. They could, over a period, change the very structure of industrial, economic, educational and cultural systems. They provide alternative routes to industrialization or the means of revitalizing that process. Some of them appear to be especially tailored to suit developing countries.

34. The UNIDO secretariat has studied in varying degrees of detail the implications and potential of several technological advances (genetic engineering and biotechnology; micro-electronics; informatics; telecommunication; advances in materials; energy from biomass and photovoltaic cells; space-related technologies; sea-bed mining; advances in lighter-than-air (LTA) systems, petrochemicals and machine tools). 17/ Some of these are briefly discussed below.

35. As regards genetic engineering and biotechnology, though fermentation technology has been known to mankind for hundreds of years, it is now possible, thanks to advances in microbiology and genetic engineering, to tailor micro-organisms to specific tasks. The resultant versatility and efficiency will enable a wide range of new or significantly improved products to be produced in a variety of fields, such as pharmaceuticals, energy production, agriculture, mining etc., thus offering new solutions to the basic problems of food, fodder, fuel and fertilizers. It is therefore important for developing countries to understand and acquire this technology, use the processes and revitalize their economies. The technology would also be energy-saving, of relatively low capital-intensity and easy to apply and lend itself to decentralized applications. It could upgrade traditional technologies, facilitate rural industrialization and improve the quality of life. With the adoption of appropriate safety regulations, the technology is not as dangerous as is sometimes believed to be. Thus, the new technology seems to be particularly tailored to the needs of developing countries where the turnover of organic material is high. If properly used, genetic engineering and biotechnology could open up a new path to industrialization.

36. It is now generally agreed that the importance and relevance of micro-electronics is such that the question is not whether micro-electronics should be introduced in the developing countries but how. It is relevant to developing countries in many respects because of its far-reaching effects on the productivity of industries, its ability to simplify and impart flexibility to manufacturing and industrial operations, its contribution to the improvement of the quality and cost-effectiveness of goods for the export market and its strategic value for the oil, power and defence industries etc. At the same time, a major factor is the direct impact of micro-electronics on the quality of life through applications that could, for example, raise the public health, medical and educational levels in a country. The manufacture of chips is complex but application of the technology is less difficult.

37. The impact of micro-electronics on employment could, however, be many-sided. On the one hand, owing to the adoption of micro-electronics in developed countries, the international competitiveness of developing countries could be eroded, with a consequent loss of employment. As computerization of services increases in developing countries, the scope for absorbing surplus labour in the tertiary sector is likely to be considerably reduced. On the other hand, there is the compensatory effect that internal use of micro-electronics in the developing countries could have through the creation of new activities and skills. Employment could also be generated in the micro-electronics industry and in the production of software for local requirements and in local languages. On the whole, while micro-electronic applications might lead to a reduction in employment in some sectors and cause hardship at micro levels, the benefits to be gained by the national economy as a whole are such that the loss of some employment should not stand in the way of their introduction.

38. Currently, there is increasing flow of micro-electronic products into the daily life in developing countries and much of the imported capital goods and other equipment has micro-electronic circuitry built into it. The costs of micro-electronic components and systems are declining. At the same time, the technological gap between developed and developing countries in this field

is growing. Unless the developing countries take measures to build up an endogenous capacity, there may be an indiscriminate import of technologies and products and the products and systems developed may not necessarily be relevant to the needs of the developing countries. Micro-electronics is a multidisciplinary, multi-institutional technology and developing countries have a choice of several entry points (e.g. applications, manufacture of components and production) and can select the degree of penetration that corresponds to their objectives, needs, resources and capabilities.

39. The "make-or-buy" alternative is growing more complex. With the increasing integration of chips, the dividing line between components, systems and software is becoming more and more blurred. Chip design and software capabilities have become essential for a mastery of the technology. As vertical integration and internationalization of markets are dramatically increasing, "barriers to entry" are becoming more severe. Developing countries nevertheless enjoy a clear advantage, due to lower costs, in regard to skilled professionals, provided they are trained in sufficient numbers and are encouraged to remain in the country. Capabilities in software could lead to substantial savings in imports, as well as contributions to exports.

40. The activities related to outer space undertaken by several countries have resulted in the development of a variety of technologies, whose potential extends beyond the space programmes themselves. That the application of such technologies can have important benefits for developing countries in such fields as communication, remote sensing and education is well recognized. In addition, the "spin-off" of technologies developed to contribute to space programmes can have a variety of applications in several industrial fields. Mention may be made of developments in micro-miniaturization, automatic control, systems engineering, reliability analysis and new materials of hitherto unattainable properties, which have now found their way into many applications in several walks of life. Other "spin-offs" could help, for example, in food preservation and processing, either through new techniques or by improving traditional practices. In regard to metal cutting, shaping and forming, several new and easy-to-handle tools have been devised, which could be used effectively by any existing machine shop or small metal-welding facility in a developing country. In all such cases, attention has to be paid to the scale of production and the adaptation to developing countries' needs. 18/

41. Technological advances are being made in virtually all groups of materials, including metals, polymers, ceramics and composites. In metals for example, high-strength low-alloy steels and powder metallurgy could have an application in developing countries. The development of fine ceramics has opened up a number of new areas of application, where light, strong, hard and temperature-resistant materials are needed. A significant advance in polymers is the technique of mixing plastic with fillers, which: (a) reduces the amount of petrochemical feed-stock needed; (b) uses up waste products; and (c) may lead to an improvement in the functional properties of the material. A number of inorganic and organic substances can be used as fillers. Another major development has been in the field of fibre-reinforced composites.

C. A possible response

42. While the acquisition of possibly inappropriate technologies stemming from technological advances would be easy, simply following the current pattern of technology transfers, the task of harnessing the technological advances to new patterns of industrial and economic development is by no means simple. It will call for new perceptions and instrumentalities of action both at the national and international levels and, in particular, the will and commitment of policy-makers at the highest levels. Here is an opportunity to strike an alternative path of technology development and to use the scientific and technological knowledge made available by the advances to solve problems unique to developing countries. It is here that the true success of technological advances will lie and that international co-operation will face an acid test.

43. The starting point of the response of developing countries to technological advances should be a keen technological awareness of the potential and implications of the advances, not only in general terms but with specific reference to the conditions, resources and development objectives of each country. Such awareness is required for policy-makers as well as for the industry, the scientific and technological community and the users at large. Actions to be taken by the developing countries and international action to help those countries must, however, extend far beyond sensitization programmes, to a larger set of basic actions.

44. Every developing country needs to take concrete short-term and long-term actions. Short-term actions would include the forecasting and assessment of the socio-economic impact of technological advances, a careful choice of technologies and equipment to be imported, and a strengthening of the negotiating capability for their acquisition. These actions are urgently needed in order to avoid creating ab initio irreversible distortions of the industrial and technological structure. Long-term actions will address themselves particularly to strengthening technological capabilities and will call for imaginative attempts to apply the technological advances to improving the standard of living and upgrading the general technological level of the population as a whole. Taken together, such responses should be a strategic activity, involving, wherever necessary, structural changes in the industrial and economic development of the country but weaving them into the development vision of each country.

45. A new line of action for the developing countries would be to establish appropriate mechanisms for forecasting, monitoring and assessing, individually or collectively, technological trends and their implications for economic and social development and for developing, formulating and implementing policies to maximize the potential benefit of the new technologies and to avoid their adverse consequences. 19/ Such an assessment could be an important input to industrial, technological and general development planning and the formulation of industrial, technological, commercial and fiscal policies and to decision-making on industrial projects. It could also reveal how far the new technologies may be used to revitalize the development process in critical sectors. For this, however, adequate methodologies and instrumentalities have to be developed. Certain suggestions in this respect are made in paragraphs 59 and 103 below.

46. At the same time, it must be remembered that high technology cannot be thought of as an escape route from the problems of development, nor can the developing countries follow blindly the high-technology path opened by the industrialized countries. High-technology options have to be placed within the range of available technology options, ranging from the traditional to the advanced. Developing countries may have to adopt and manage a technological pluralism that will be optimal in the light of the objectives, problems and limitations of each country. High technology should also be used not only to start feasible new industrial activities but to upgrade the general industrial and technological capability of the country, including its traditional or decentralized activities. This could help to eliminate human drudgery, raise the prospects for substantial increases in productivity, decentralize production and marketing and introduce better quality control.

47. No uniform prescription can be sought or applied for countries at different levels of development, nor indeed for each type of technological advance. Any approach to the question of technological advances and development would be unrealistic if it did not take into account the different levels of development in developing countries and the different goals, priorities and resource endowments. There are perhaps a dozen developing countries that could absorb technological advances more successfully than the others. The situation of all types of developing countries has to be considered. Countries may have to follow selective and differential approaches, and each country may have to decide for itself the point of entry, degree of penetration, source of inputs, linkages, vehicles of implementation etc. However, in an interdependent world economy, all countries need technological awareness. Whatever the level of development, a minimum level of competence is needed to deal with emerging technologies within a realistic time horizon and effective national groups should be set up for this purpose.

48. The barriers to entry into the high-technology field include: inadequate or inappropriate education and research facilities; a shortage of scientists of the necessary calibre; an unsuitable climate for innovation and investment; a lack of scaling-up capabilities; an absence of standards; and cumbersome procedures and regulations. The building up of basic scientific capabilities in high-technology fields is a matter of urgent necessity, since, in genetic engineering for example, the distinction between basic and applied research can wear very thin.

49. It is most important to consider the agents of technological change and application. These would be enterprises, government departments and a wide range of professionals, such as agricultural extension workers, public health personnel etc. It is through them that the actual diffusion of technological advances will take place. The introduction of new technologies will be governed primarily by economic considerations combined with a number of technological and social factors, involving, inter alia, acceptance of new products and technologies by producers and users. For example, enterprises that are thinking of introducing new technologies will be concerned with investment requirements, the replacement of existing usable equipment and cost, competitiveness and technical advantage. Similar considerations will be applied by users. For them, the new technologies should result in products that are better than existing ones in terms of effectiveness and cost and can fit into the general milieu in which their use takes place. In general, the economic environment, social and educational context, government and management support will govern the pace at which the technologies are introduced.

50. Developing countries at different levels of development may not necessarily have to aim at achieving the same level of competence, but it should be understood that each country will strive to reach a high level of competence in the longer term, although in the short run it may seek a given level of competence in particular technologies and productive sectors. Within the country itself, the level of entry point may vary for different areas, as shown in schematic form below.

Entry points

Minimum level:	awareness, continuous monitoring, critical and relevant technological intelligence; identification of needs and relevance; the ability to assess, select, negotiate and utilize technology; autonomous decision-making;
Medium level:	the above and, in addition, the ability to adapt or generate technology;
High level:	all the above, as well as the capability for commercialization, design, manufacture of equipment, and participation in competitive international markets.

The foregoing levels and elements should be viewed in a dynamic framework, in which each country selects its entry point and progresses from there. The human resources corresponding to each level should be developed concurrently.

51. In the context of the emergence of technological advances it is clear that a reorientation of approaches and actions will be necessary in every aspect of the development and transfer of technology, in particular those discussed in chapter I above, namely, the selection and acquisition of technology, technological development, human resources and technological policy. Given the scarce resources of developing countries, the penalty for inappropriate action is high, while fragmentary action may provide the illusion of a response, without the desired results. A total framework for national action is needed in which the response to technological advances will be integrated into existing technological policies or efforts while the deficiencies of the latter are rectified. Industrial sectors will concurrently need to be reviewed in regard not only to the new industries to be set up but also to the implications for existing industry and the possibilities for their technological upgrading. The framework for action must therefore encompass both technological advances and existing technologies, as well as the wide range of industrial sectors, in a long-term perspective and with dynamic interlinkages between industry and technology. Industrial technology for the 1980s needs this type of integrated framework for action and the building up of such a framework to respond to technological advances must be regarded as one of the major responsibilities of Governments in developing countries in the 1980s. The essential steps in building up that framework are discussed in the next chapter.

III. INDUSTRIAL TECHNOLOGY FOR THE 1980s: A FRAMEWORK FOR NATIONAL ACTION

52. A framework for national action to strengthening the technological capabilities of developing countries was submitted by the secretariat as a contribution to the United Nations Conference on Science and Technology for Development (A/CONF.81/BP/UNIDO) and subsequently to the Third General Conference of UNIDO. The framework was proposed since the technological system in a country is composed of a number of institutional and structural elements, none of which can succeed in transferring or developing technology in isolation from other elements; it was also intended to help avoid piecemeal action, or the incorrect understanding that, once action has been taken in one or two directions, the rest will take care of itself. The framework was designed as a series of sequential and operational steps, within which each developing country, in the light of the progress made by it and in accordance with its own conditions and objectives, could choose its own starting point. That framework, while still valid and more necessary than ever, needs to be viewed in the light of prevailing dynamic technological trends, so as to help developing countries to approach the question of industrial technology for the 1980s. Each developing country may select its own comprehensive set of measures within the redesigned framework; in the meantime, it could take certain interim steps, in particular keeping a close watch on imports of technology deriving from technological advances, in order to avoid basic distortions, for example in regard to the import of computers and telecommunication technology.

53. Several factors have to be taken into account in evolving a framework for national action for the 1980s. First, national actions have to be based on both a technical and a socio-economic assessment of technologies. The assessment should extend beyond the implications and potential of a particular technology at the global level to include its relevance to national development objectives and local conditions. In a period of dynamic technological change, such assessments have to be made in a context of uncertainty.

54. Secondly, the framework has to be integrative in many respects. It should integrate technological advances into the existing technological system of the country; it should integrate modern and traditional technologies so as to make available a plurality of technologies suitable to the conditions prevailing in the country; and it should integrate the technological system into the industrial structure, since particularly in the light of the technological advances industrial and technological policies tend to be two sides of the same coin. In addition, it should integrate the various actors in the industrial and technological system, namely, the Government, industry, the scientific and technological community, labour and the users at large. It should, moreover, promote multidisciplinary multi-organizational and multisectoral approaches to industrial and technological development.

55. Thirdly, the framework has to be innovative and reformatory. Several existing systems and ideas may have to be displaced, for example, obsolete industries and some elements of the education system that are no longer relevant. The training of industrial and technological manpower will also have to be reviewed, since technological advances are leading to a new pattern of skill profiles.

56. Fourthly, the framework for national action has to be dynamic. It should be forward-looking, in order to take note of anticipated technological changes and provide for a greater role for technological innovation and interaction. The industrial sectors should be dynamic and flexible, so as to adjust to technological change and derive benefits therefrom.

57. The emergence of technological advances has thus provided a valuable opportunity for developing countries to re-examine at one and the same time their industrial and their technological structures.

58. The original framework for national action comprised four self-evident steps (see A/CONF.81/BP/UNIDO, para. 55):

(a) Achievement of a broad consensus on the desired mix of technology and the pattern of national technological capabilities;

(b) An assessment of the present status of technological capabilities and identification of gaps and shortcomings;

(c) Strategy formulation in terms of policies, programmes and institutions together with the financial and manpower resources needed for its implementation;

(d) A reassessment of the coherence of the ways and means as well as arrangements for co-ordination and monitoring.

The considerations that are relevant for the 1980s in regard to each of these steps are referred to briefly below.

A. A national consensus on the technology mix

59. A national consensus on the technology mix is more urgent today than ever before in view of the emerging technological advances and their socio-economic implications. Such a mix must be derived from the country's development objectives to secure the pattern of industrialization that it wants. While the manner in which a national consensus on the technology mix is reached will vary according to the political and economic systems prevailing in each country, all countries need to involve the various actors in the industrial and technological system and make the public at large sensitive to the implications (beneficial and adverse) of the technological advances. They may also require a supporting mechanism through which decisions on the technology mix are reached. Though the scope of the mechanism may vary with the size of the country and its conditions, as a minimum, an interdisciplinary unit of say, 6-12 professionals could be established at a close to high policy-making level. The unit would have monitoring and assessment functions, drawing upon the expertise of individuals and institutions within and, where necessary, outside the country. Within the country, expertise may be drawn from economists, scientists and technologists, social scientists, systems analysts, bankers, industrialists, management experts etc.

B. Assessment of present status and future requirements

60. The present status of technological capabilities must be reassessed, concentrating on the new requirements for the application or development of the technological advances within the context of the mix of technologies that the country aims to achieve. The Forum recommended that each developing country should review the current status of its technological capabilities and give them a new orientation so that it can respond to technological advances (see ID/WG.389/6, para. 16). The Workshop on Institutional and Structural Responses of Developing Countries to Technological Advances, held at Dubrovnik from 31 May to 4 June 1983, identified, accordingly, the actors, activity modules and activities involved in the industrial and technological system and suggested actions to be taken (see ID/WG.401/7). The salient points are discussed below.

1. Upgrading endogenous technologies

61. Now more than ever, a survey of the state of endogenous and, in particular, traditional, technologies is necessary in order to find out how they can be upgraded through the use of modern science and technology. The upgrading could best be achieved by making the practitioners of endogenous technologies aware of the potential of the technological advances to upgrade their capabilities, particularly through selected "spotlight" applications. Technological advances and their potential for developing countries add a new dimension to the concept of appropriate technology developed by UNIDO when it drew up a co-operative programme of action in this field. 20/ According to this concept, different technologies could be appropriate to developing countries depending on the development objectives, resource endowments and conditions of application of each developing country. Thus, a wide range of technologies, ranging from the modern to the traditional, could be appropriate. Alternative technologies could be identified even in some ostensibly capital intensive sectors, e.g. mini-steel plants, mini-fertilizer plants and mini-paper mills, which could meet relatively small and dispersed demands. A key area of effort might be to identify how modern technologies could be applied to improve such technologies and traditional decentralized industrial activities still further. 21/ Small industries, small energy systems, including mini-hydro units, and agro-industries in general are areas that it might be possible to upgrade through the application of technological advances. National technology services delivery systems 22/ could serve as vehicles for the diffusion and beneficial application of technological advances. In agro-industry, new concepts may have to be introduced involving, for example, a systems approach towards the application of various technologies for the complete industrial utilization of agricultural crops (in the case of paddy, the utilization of rice, rice husk, rice bran, paddy stock etc.). Such approaches will be useful in evolving a biomass-based strategy for industrialization, to which reference is made later in this chapter.

2. Integration with industrial sectors

62. The technological status of individual industrial sectors in a country must be assessed, as well as such areas of technological service capability as consultancy, design, construction etc. At the same time, the possible impact on these sectors of technological advances, individually and in combination, should be evaluated (see ID/WG.389/3, pp. 23-28). In the process, certain lead sectors for national industrial and technological growth (such as agro-industries, capital goods industries etc.), as well as "niches" for competition in external markets could be identified, as could the industrial sectors that provide support to the above. As the First Consultation on the Capital Goods Industry showed, there are different levels of technological complexity in the manufacture of capital goods, and developing countries could move from one level to the next. 23/ Where market demand is small, the role of small-scale industries and efficient technologies will therefore require attention.

63. The feasibility of introducing industrial activities relating to micro-electronics, genetic engineering and biotechnology and information processing should also be investigated. Some specific policy measures in this respect are discussed later in this chapter.

64. The survey of the present status of industrial sectors could provide a convenient point for the integration of industrial and technological policies. Such an integration should, inter alia, ensure a coherent and interactive industrial structure, aim at achieving comparative advantage through the improvement of productivity and quality, introduce flexibility and a capacity for modernization and restructuring of the industrial structure and generate and maintain a climate for innovation in both larger and smaller enterprises. The lines of industrial restructuring must be derived from the dynamics of technology and of internal and external demand. 24/ Actions to be taken may include long-term plans for industry, involving such considerations as pattern of technology induction; size of the firms; level of integration; complementing industrial linkages with technological linkages; industry awareness programmes; incentives or outright financial support for research and development etc. At the level of the firm, actions would include long-term corporate planning; changes in patterns of management and decision-making; information systems; alterations of production lines; in-house research and development capabilities and links with research and development centres and universities; and quality control. A clear concept of the industrial structure must go hand in hand with a concept for the transfer and development of technology, and in particular for the introduction of technologies arising from the technological advances. Where periodical industrial or general economic development plans are drawn up, they may be preceded by and incorporate a forecasting and assessment of technology trends (as for example in the USSR) 25/ or complemented by a technology plan.

3. Review of technological institutions and their linkages

65. The whole range of technological institutions, their relevance, effectiveness and interaction, now have to be reassessed. A certain amount of fresh institution building will also be required. These institutions have to

provide for interaction with industry and may have to be innovative. Among existing institutions, interlinkages and trans-disciplinarity should be encouraged. They should also have trans-sectoral and trans-organizational links, so that teamwork and mobility (not only between disciplines but also between research and development and the production sector) may be promoted. The role of universities needs to be examined, as they could be an important repository of knowledge on technological advances if their structures and methodologies for teaching and research are changed from traditional to more appropriate practices.

66. By and large, three types of institutional functions may be required in developing countries:

(a) Forecasting, monitoring, assessment, regulation and policy formulation at the macro level;

(b) Information, evaluation and consultancy services at the micro level;

(c) Technological development, adaptation, commercialization, extension etc.

67. Where developing countries, particularly the small or least developed countries, find it difficult to establish a wide range of technological institutions, the concept of a core group could usefully be explored. After a few priority areas have been identified, a small core group of say 10-15 persons could be formed in the country for each priority area, with linkages to similar groups in other countries. The group could keep the country informed on the state of the art in a given area and provide information, awareness and intelligence. Two or three such groups could be formed, dealing, for example, with genetic engineering and biotechnology or micro-electronics. They could be provided with common facilities and allowed to grow into centres of excellence or advanced institutes. In addition, small groups may be constituted for the monitoring and assessment of technology and for consultancy, as also appropriate technology delivery systems. The purpose of such groups will be nullified if there is a frequent turnover of personnel.

C. Strategy formulation

68. After a survey has been made of the existing status, strategy should be reformulated through appropriate policies and programmes and the creation or restructuring of institutions. Special attention may have to be paid in the 1980s to the following points.

(a) Policies for the selection and acquisition of technology

69. A policy for the selection and acquisition of technology is essential, particularly for technological advances, and should cover not only technology but also equipment (which embodies technology) and foreign investment (which is a vehicle of technology and invariably predetermines it). Although each

country may have its own approach towards determining the extent of promotion or regulation of foreign technology, as a minimum, a continuous and systematic monitoring of foreign technology inflows will be needed to ensure a pattern of industrial and technological growth consistent with the country's requirements and objectives.

(b) Policy for technological innovation

70. A policy for promoting technological innovation is essential. In developed countries innovation is seen to be the key to international competitiveness. The policy should extend beyond traditional support to research and development in government institutions and should be closely woven into the industrial structure. Several developed countries have adopted specific policies for technological innovation in the fields of technological advances. Several models of policy measures involving incentives or financial support for innovation also exist in the advanced developing countries. 26/ Special policies for the encouragement of technological service capabilities are essential, particularly for the promotion of qualified national consultancy groups that can advise on the selection and application of technology both at the micro and macro levels. These policies should be backed by special programmes with appropriate financial support.

(c) Policies for human resource development

71. The nature of the technological advances has reinforced the need to strengthen scientific capabilities. Education and training policies have to be looked at critically. Trans-disciplinarity should be encouraged, as should new approaches to teaching, making use of modern teaching aids and technological data. At a more fundamental and basic level comes the upgrading and reorientation of education at the school level. The widespread use of microcomputers, the restructuring of courses in biology, the emphasis on an integrated approach to scientific subjects, cultivating awareness of global environmental considerations and concern for the social implications of recent technological advances call for a true revolution in the educational system. 27/ The major problem here is the retraining of the teaching corps to perform these momentous tasks. The curricula of primary and secondary schools must be strengthened through the mechanism of teachers possessing a better understanding of the emerging technologies and their applicability to the development process. Science clubs, science centres etc. may also serve this purpose. Computer education will need to be introduced into several educational programmes at the earliest possible level. It should, however, be remembered that introduction of new teaching aids, particularly computers, may involve considerable expenditure in foreign exchange and there may not be the necessary maintenance facilities. These problems should be thought through carefully in drawing up specific programmes.

72. Awareness and popularization programmes should extend to professional societies, trade unions, industrial enterprises and government bodies, as well as to potential end-users in industrial and service sectors, administration and the public at large.

73. Policies for halting and reversing the "brain drain" have to be considered. Several developing countries are now offering facilities for nonresident scientists and technologists to return and work in their home countries. The possibilities of using such non-residents without necessarily bringing them back to the home country could also be explored. A network system providing access to information, research and development, engineering design and consultancy services and advisory services could be developed at a relatively low cost.

(d) Specific policies for micro-electronics and biotechnology

74. Specific policies will need to be developed for high-technology areas, such as micro-electronics, telecommunications and genetic engineering and biotechnology. For example, a national policy for micro-electronics development might include one or more of the following: public awareness campaigns; concentrated programmes for education and training; support for the manufacture of electronic components and the application of micro-electronics in production and services; public procurement policies; research and development subsidies; research contracts; low interest loans; investment grants etc. 28/ Micro-electronics and telecommunication policies have to be harmonized in view of their close interrelation. Software as an industry could be promoted through systematic measures. 29/

75. Taking into account the potentialities of genetic engineering and biotechnology, many developing countries will find it useful to develop an integrated biomass-based strategy for industrialization, covering industrial, energy and other uses of biomass. This would involve national policies for integrated biomass use in industry, energy and other sectors, a programme for national biomass generation and the identification of suitable technologies, particularly decentralized ones, that can be tailored to the type of biomass and the wealth of micro-organisms available. A biomass-based industrial strategy should be an important component of the total industrialization strategy of a developing country, particularly since it can meet local demand, help and develop the rural areas, avoid imports and the use of foreign exchange and create a certain endogenous industrial momentum, which could be maintained irrespective of the international economic situation. It would provide an important means of decentralized industrialization, which has been emphasized in several forums as a means of widely distributing the benefits of industrialization. Considering the vulnerability of import-dependent industrialization, a biomass strategy for industrialization should be considered as one of the corner-stones of industrial policy for the 1980s. 30/

76. A "materials policy" to guide decisions on major projects involving the production or use of selected materials also needs to be evolved. 31/

(e) Structuring and management of demand

77. The structuring and management of demand can be considered to be a goal of public policy. The "technology push" exerted by the technological advances in developing countries places upon Governments the responsibility of watching out for undesirable impacts on national values and way of life and to see to

it that it is a useful and orderly "demand pull" that is shaping the national market for these technologies. The business community needs to be protected from making unwise investments at the wrong time, as well as dissuaded from the temptation of easy profit through the importation of inappropriate or even harmful products that may result in heavy social costs.

78. In many developing countries, the State is the major consumer and source of national demand. This provides opportunities for a controlled and orderly diffusion of technological advances, whereby their introduction into the public administration, social services and public utilities will be in keeping with national values and life-styles.

79. Furthermore, public procurement - usually involving large-scale contracts - should stipulate the use and development of national capabilities to the maximum possible extent. This would accelerate the upgrading of national institutional and individual capabilities and facilitate their mastery of the technological advances.

(f) Financial resources

80. The need for a greater allocation of funds for science and technology in developing countries assumes greater relevance with the emergence of technological advances. These financial resources can be divided into: (a) expenditure for research and development support; (b) the social and infrastructural investments needed, such as investments in education and training, technological information services etc.; and (c) investment required for new enterprises or for new equipment in existing enterprises.

81. In most developing countries, the expenditure on research and development relates to work done in government institutions and incentives or subsidies given by Governments. Allocations from enterprises are also needed, however. Venture capital is important for the introduction or commercialization of new technologies. Private investors and the banking system need to be involved either through new technology investment companies or existing industrial development banks offering venture capital cost-free or at very low interest rates or as grants with participation in the returns from successful ventures. Financial support also needs to be provided to small, innovative firms pioneering in the high-technology field.

82. As regards point (b), Governments may have to review their existing priorities for education and training. While additional resources will have to be found, some resources could be reallocated. Enterprises may also have to allocate resources to the training and retraining of their engineers and workers.

83. As regards point (c), the investments have to be made by enterprises or public utilities, which will have to compete for the investible resources from the existing pool, but taking advantage of any revision of priorities that governments may introduce by policy. They may also have to compete in the international market with enterprises from developed countries that are going in for a new cycle of investment. Investment requirements for the introduction of technological advances may not necessarily be high (e.g. in

biotechnology existing fermentation equipment can be used); where they are high, developing countries have to take policy approaches, just as they do when they are confronted with capital-intensive technologies in other fields. In general, the question of financial resources should be looked at as part of the larger question of resources required for development and not as a constraint inherent in the introduction of new technologies.

84. About a decade ago it was suggested that developing countries might allocate at least 1 per cent of their gross national product to research and development. 32/ In view of the important role of technology in the 1980s and beyond, the knowledge-intensive nature of the technological advances and the substantial expenditure on research and development in this field incurred or planned by several developed countries, it is proposed, as recommended by the Dubrovnik Workshop, that the developing countries aim at devoting 1.5 per cent of their GNP for research and development by 1990 and reach a minimum level of 2 per cent by 2000. The cases of Mexico and the Republic of Korea show that rapid increase in the share of research and development in GNP is feasible. Developed countries, through appropriate provisions and a reorientation of their aid programmes, could help to attain this level. Notwithstanding the "spin-off" of military research for civilian use, the reduction of military expenditure will also release funds for scientific and technological development.

D. Co-ordination and monitoring

85. The fourth step in the framework for national action is to ensure consistency, co-ordination and monitoring. These functions acquire particular significance both on account of dynamic technology trends and on account of the increasing socio-economic implications on the technological advances. A small high-level interdisciplinary group close to the highest policy-making levels is necessary to co-ordinate, review and update the strategy. The traditional governmental structures are not necessarily best suited for taking and implementing decisions on technology. A review of existing structures and setting up of co-ordinating mechanisms is therefore particularly necessary.

E. Summary

86. The Forum wished to bring to the attention of the Fourth General Conference of UNIDO the need for industrial and technological policies for the 1980s and beyond to be framed in the light of the potentialities and implications of technological advances. In line with the emphasis placed by UNIDO on stimulating and assisting action at the national level, the need for a possible framework for this purpose has been urged, highlighting the elements that are particularly relevant to the emerging technological advances. The secretariat proposes to elaborate the foregoing analysis into a comprehensive framework with a series of sequential and operational steps, so that developing countries can use it as a guideline for national action in accordance with their own conditions and requirements. Particular emphasis has been given in the discussion of the framework to the monitoring and assessment of technologies, regulation of technology imports, modalities for

integrating industrial and technology policies and structures, new approaches to innovation and institution-building and specific policies in the areas of micro-electronics, and genetic engineering and biotechnology. The usefulness of exploring a biomass-based strategy as an essential component of industrialization has also been highlighted. A developing country will naturally have to choose the lines of action it considers appropriate and urgent in its own context. Some countries may have already taken some of the steps discussed above but may also wish to take other necessary measures. Other countries may be selective, bearing in mind prevailing conditions and the resources available to them. Even small and least developed countries may, however, have to give thought to establishing small groups for the monitoring and assessment of technology, monitoring of imported technology and the establishment of interdisciplinary core groups in selected technological areas and industrial sectors, which would be of strategic advantage to the country and which could be expanded later. Most countries will find it worthwhile to consider applying technological advances to a biomass-based strategy for industrialization and also to relatively simple micro-electronic applications. Countries with a relatively developed industrial and technological infrastructure may find a wider scope for micro-electronic applications.

87. It is apparent that developing countries will require assistance in one or more respects in formulating and implementing a framework for national action in the 1980s and in particular in responding to the technological advances. This poses additional challenges for international co-operation and places additional responsibilities on UNIDO, which are briefly discussed in the ensuing chapters.

IV. INTERNATIONAL CO-OPERATION IN THE 1980s

88. Recommendations for international co-operation in technology have been made in a number of forums. They include the Vienna Programme of Action 33/ and the Lima 1/ and New Delhi 2/ Declarations and Plans of Action. Proposals for technological co-operation among developing countries were also elaborated in the Caracas Plan of Action (A/36/333, annex, paras. 7-26). These recommendations cover a wide range. While they are of particular importance and should continue to be implemented vigorously, the changing scene of technology calls for new dimensions to international technological co-operation in the 1980s. Before discussing these new dimensions, a few brief comments may be in order on the direction taken by international co-operation so far and possible improvements to alleviate the problems identified in chapter I.

A. Present direction of international co-operation

89. At the enterprise level, considerable technology flows continue to occur over a wide range of industrial sectors through turnkey plants, supply of equipment, direct investment, licensing etc. Measured in terms of technology fees and payments, the volume of trade in technology to developing countries rose to over $US 2 billion by 1980 and constituted some 14 per cent

of the world's turnover. 34/ In spite, however, of some improvement in the negotiating capabilities of regulatory agencies and enterprises, costs and conditions of technology contracts and access to technology continue to be matters of concern to the recipients. The technological components of the contract, such as specification of services to be rendered, training, access to improvements, research and development assistance, patent rights etc., are still matters of concern to developing country enterprises. In the meantime, new elements of technology transfer are emerging, for example in software and in regard to micro-organisms.

90. Intergovernmental co-operation agreements in science and technology have been concluded between a number of developed and developing countries. These address themselves to training and assistance for scientific institutions but not necessarily to the production systems. Intergovernmental project aids stress the training aspects in certain cases (particularly centrally planned economies) but do not as a rule incorporate specific science and technology components. In official development assistance (ODA) from developed countries, the share of technical assistance devoted to the industrial sector is very low, roughly 5 per cent, and therefore even less for industrial technology (see UNIDO/IS.370, p. 65, table 7). Co-operation between educational and research institutions of developed and developing countries continues but the number of trainees and disciplines covered need to be increased. Technologies and technological information are freely available in the public domain in developed countries, but no special measures have been taken in most countries to transfer such information to developing countries. In recent years there has been a trend in a few developed countries to encourage small and medium-sized firms to transfer technology to developing countries and to adapt their technology to the conditions of these countries.

91. Some major issues of international co-operation remain unresolved. An international code of conduct on the transfer of technology promoted by the United Nations Conference on Trade and Development (UNCTAD) is still being negotiated. Issues relating to the revision of the Paris Convention for the Protection of Industrial Property being discussed under the auspices of the World Intellectual Property Organization (WIPO), are also still to be resolved. The United Nations Financing System for Science and Technology for Development has been established but at a far lower level than that envisaged by the United Nations Conference on Science and Technology for Development. Some progress at the sectoral level has, however, been achieved under the UNIDO System of Consultations in regard to the fertilizer industry, where two model contracts were finalized by an international group of experts for consideration by a consultation meeting after having been discussed in depth and negotiated by reputable engineering contractors and experienced purchasers. 35/

92. As regards co-operation among developing countries, some measure of co-operation has been achieved at the industrial level and a greater amount at the intergovernmental and educational and research institutes level. Co-operation between technology registries under TIES is another case in point. Virtually all regional integration and co-operation schemes have introduced programmes and mechanisms for the development and exchange of industrial technology, co-operation in the field of human resources development, search for technology in the international market etc. In Latin America, the Andean Group has enacted a package of measures, based on a

technological subregional policy and including a technological information system (SAIT); a series of programmes of technological development (PADT) (which so far have been executed in the copper, forestry and food sectors); revision of the patent legislation through a common regulation; and a regulation for foreign investments and technology transfer that harmonizes the treatment provided to foreign suppliers. In Africa, the following institutions are already in operation: the African Institute for Higher Technical Training and Research (Nairobi), the African Regional Centre for Engineering Design and Manufacturing (Ibadan) and the African Regional Centre of Technology (Dakar). The Economic Commission for Africa (ECA) is at present involved in the creation of an additional organization, the African Regional Centre for Industrial Consultancy and Management. Important programmes in the region, covered by the Economic and Social Commission for Asia and the Pacific (ESCAP), include the Regional Centre for Technology Transfer, which supports the technological capabilities of national centres, and the Regional Network for Agricultural Machinery, which provides extension services, standardization and quality control. In spite of these achievements, considerable headway has to be made to achieve the goals set in the Caracas Declaration and Plan of Action.

B. Improvement of existing co-operation

93. Since developing countries acquire much of their technology from the developed countries, the transfer of technology between them will continue to be an important issue. Here the "transparency" of the international technology market and access to technologies on fair, equitable and acceptable terms and conditions should be important elements in international co-operation. In addition, technology transfer contracts should provide adequate facilities for training and for adaptation and endogenous research and development to be provided by the supplier: these are particularly important factors in strengthening the technological capabilities of developing countries. Given the figure quoted in paragraph 89, even if the suppliers of technology earmarked 5 per cent of the technology fees and payments for research and development in the respective host countries, it would amount to $US 100 million per annum. Aid programmes in developing countries should also earmark adequate amounts for the development of science and technology and in addition, in important project aid programmes, whether promoted by Governments or by international aid institutions, financial provisions should invariably be made for the absorption and assimilation of the technology by the recipient country. Governments of developed countries could also improve the facilities for making the technologies and technological information available in the public domain in those countries accessible to developing countries. They could also locate in the developing countries such research and development in the public domain as is of particular relevance to developing countries. This might also, to some extent, reduce the overseas training costs for developing countries. Technological co-operation among small industries of developed and developing countries should be further enhanced in both the traditional and high-technology areas.

1. Strengthening of TIES

94. Technological co-operation among developing countries is still often confined to the exchange of information, though several examples of regional and subregional initiatives in the field of technology exist and more should be encouraged. Implementation of the Caracas Plan of Action has to be accelerated. In particular its recommendation that the TIES should be strengthened and expanded needs special attention, as this unique form of co-operation among technology transfer registries has contributed to strengthening the technological capabilities in the acquisition of technology. All developing countries that wish to do so, even if they do not have a technology transfer registry, could be encouraged to be associate members of the TIES system so as to benefit from the exchange of information and experiences other than those subject to reciprocal arrangements. Co-operative training programmes in the strengthening of negotiating capabilities could be initiated under the auspices of TIES. The possibility of technology transfer among States members of TIES could also be systematically explored.

2. Consultancy consortia

95. The importance of such technological services as consultancy, at both the micro and the macro levels calls for new forms of co-operation among developing countries in these areas. 36/ With the availability of a diverse pattern of consultancy firms already established in developing countries, the outlook for the formation of consultancy consortia is promising. This type of co-operation would involve an exchange of personnel, joint work on projects, joint ventures between consultancy firms and an exchange of information relevant to the consultancy profession on a regular basis. Such a scheme would help the consulting firms by accelerating the development of their own capabilities and thus increasing the acceptability of their expertise in the developed countries. This type of co-operation among consultancy firms of developing countries does not preclude co-operative arrangements between consultancy firms from two developing countries and one from a developed country. For example, say, the consultancy firm from a developed country can provide the basic engineering package and sophisticated technological solutions to engineering problems, while the two firms from developing countries could pool their resources and jointly provide the necessary expertise for detailed design and engineering, project management etc. As emphasized in the Buenos Aires Plan of Action for Promoting and Implementing Technical Co-operation among Developing Countries, 37/ a broad exchange of experiences in this field among developing countries is an indispensable component of national and collective self-reliance.

96. Following two expert group meetings held in the ESCAP region by UNIDO, a network of consultancy in Asian countries has been proposed as a framework for co-operation among consultancy firms in the region. The Caribbean Technology Consultancy Service has been functioning for some time as a co-operative endeavour among the countries of the Caribbean region, with the support of the Caribbean Developing Bank.

3. Creation of a network mechanism for technology export efforts

97. The export of technologies between developing countries should be considerably accelerated. Consideration might be given to the establishment of an international network mechanism that would link institutions in developing countries that are concerned with technology exports, including national research and development corporations, and facilitate their commercialization and licensing. This type of mechanism could help to disseminate information on the technologies developed by the respective countries. A feasibility study on the subject could be useful.

4. Preferential arrangements

98. Developing countries could also give further consideration to preferential arrangements for the mutual transfer of technology and identify one or two specific sectors that could initially be the subject of such preferential treatment, for example, leather, food processing and oils and fats.

C. New dimensions of international co-operation

99. In regard to the international technology market, it can be said that the development costs of high-technology tend to be high; uncertainties in the initial period are rife, and the scales of production, and hence the market to be captured, large. As a result, only large firms with enough capital and experience of international operations are in a position to commercialize the technologies, though small and medium-sized firms lead the initial spurt in innovation. Broadly speaking, there is a new concentration of technologies in certain types of firms. Computer firms, semiconductor firms and, to some extent, telecommunication firms have control of the micro-electronic and computer fields and in general of information technology. Chemical and pharmaceutical, food processing and oil firms have shown considerable interest in genetic engineering and biotechnology. The oil firms have also shown interest in solar and biomass technologies. In telecommunication, an element of competition has crept into a previously oligopolistic structure. The net result is that a new alignment of the international technology market may emerge. It is to be noted that genetic engineering and biotechnology development may by and large be controlled by chemical, pharmaceutical and oil transnationals, which would view the new technologies as an option that they might or might not use in the light of their global strategies. Thus, even though some of these technologies might be of particular relevance to developing countries, the strategies of transnational companies may not promote their application to those countries.

100. The emergence of technological advances highlights certain aspects of international economic relations. First, developing countries have to take note of the changing technology market. In this new configuration, transnational companies could be expected to have control over not one group of technologies but several related technologies, for instance in the energy, chemical, pharmaceutical and biotechnology fields etc. Secondly, in the case

of biotechnology and solar and biomass energy, the markets are to be found essentially in developing countries. In many high-technology areas, economies of scale and international competition would sooner or later require that products and technologies be exported to developing countries. As a study on international competition in advanced technology puts it: "The latest area for intense competition in advanced technology industries is the Third World's emerging market - the same 113 countries that account for about 40 per cent of the world's GNP. Sales to the newly industrializing nations are a powerful determinant of success in international competition in advanced technologies. The nations or firms that make initial sales to an emerging nation tend to continue as preferred sources". 38/ This fact gives the developing countries a countervailing power both in regard to the terms of acquisition and the degree of local content. Finally, in an interdependent world economy and as a simple corollary of interdependence, it is only by strengthening the technological capacities of developing countries that developed countries can hope to export to them larger amounts of technology and equipment.

1. Major goal of co-operation in the 1980s

101. International co-operation must take a new orientation, both to make it possible to use technological advances for the benefit of mankind as a whole and developing countries in particular, and to evolve new approaches to the halting and uneven development process. The beneficial application of technological advances for development should be declared to be one of the major goals of international co-operation in the 1980s, and should increasingly be the focus of co-operation between developed and developing countries, in accordance with the priorities and requirements of each developing country, enabling that country to acquire a basic technological competence for the use of such advances. Exchanges among scientists, education and training programmes, links between universities and other such means may be employed to enhance the technological capabilities of developing countries. The transfer of technology should take place without any restrictions on access and on equitable terms and conditions, involving as far as possible national participation and development. In transferring technology, adaptations of products and processes must be made, particularly since applications in biotechnology have a high specificity to local resource endowments and applications in micro-electronics have to fit specific developing country requirements and their social and cultural context. The transfer process has to be considered not as a mere transfer of knowledge between enterprises but as a means of contributing to and maximizing the benefits of global interdependence. The knowledge and information on technological advances available in the public domain in the developed countries must be made widely accessible and disseminated to the developing countries. Channels of communication and co-operation may be improved between developing countries and small and medium-sized enterprises and educational and research organizations in developed countries that are pioneering applications of advanced technologies.

102. The emergence of technological advances would, in a sense, lead to a new phase of co-operation among developing countries, which should increasingly incorporate activities relating to the acquisition of technological capability and self-determination in that field. The problems they encounter in the collection of information, forecasting, assessment,

selections, acquisition, adaptation and absorption of technological advances and endogenous development and application of such technologies will have much in common and they will therefore need to exchange information on policies and experiences. There is plenty of scope for action at international, regional and subregional levels. Co-operative programmes should extend beyond the exchange of information to collective strategies including strategies for joint negotiation and acquisition of technologies, and the setting up of common production facilities, technological institutions and programmes.

2. Forecasting and assessment network of developing countries

103. More importantly, the developing countries may have to consider together a collective strategy for their response to technological change. As a beginning, as recommended by the Dubrovnik Workshop (see ID/WG.401/7, para. 108), a forecasting and assessment network of developing countries could be created.* UNIDO could serve as a clearing house for the network. It could also contribute studies for the network and identify or promote nodal centres in developing countries, which could specialize in specific fields. The network should complement and facilitate national actions and not be a substitute for them. It could in due course pave the way for collective strategies and joint acquisition of technologies. UNIDO was requested by the Workshop to contribute to such an initiative in implementing its programme on technological advances.

3. New international mechanisms

104. The true test of international co-operation would, however, lie in its ability to harness technological advances to unique developing country applications, which would enhance the productivity and capabilities of their manpower and improve the quality of life of their people. Developing countries are at different levels of preparedness when it comes to taking advantage of the technological advances. This makes it all the more essential to devise new mechanisms of international co-operation, particularly to help the weaker countries. The possibility of setting up international centres for different advanced technologies needs to be explored as a means of strengthening national technological capabilities. One case in point is the UNIDO initiative for an international centre for genetic engineering and biotechnology, which led to an agreement (as of November 1983 signed by 28 countries) to establish such a centre. 39/ Other suggestions emanating from the Forum and other meetings include the establishment of an international centre for microprocessor applications, an international network of institutions engaged in research and development for energy from biomass, a consultative group on solar energy research and an international mechanism for monitoring developments in the field of materials.

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* Cf. the technology-specific work programme of the OECD Directorates of Science, Technology and Industry, the ad hoc working parties of the European Economic Community and the Community's Forecasting and Assessment of Science and Technology (FAST) programme.

105. There have been several proposals regarding micro-electronics. A request was made at the Forum (and earlier, at the Moscow meeting of experts) for an international microprocessor application centre to promote and disseminate developments in the application of micro-electronics for unique developing country uses and to upgrade their traditional technologies. Following a joint meeting of UNIDO and the Economic Commission for Latin America (ECLA), a co-operative Latin American programme of micro-electronics was recommended. 40/ An international symposium on the application of micro-electronics for productivity, organized by the Government of India and co-sponsored by the Asia Electronics Union and UNIDO, recommended the setting up of an Asian centre for electronics and requested UNIDO to take the necessary steps. UNIDO is also promoting a regional programme in West Asia. A detailed examination by the UNIDO secretariat has revealed the need for international as well as regional initiatives, which could match and complement each other. An international centre for microprocessor applications could provide information and advisory services to developing countries, promote applications in areas of no particular interest to developed countries, promote software development for such applications and if possible provide facilities for a silicon foundry for the production of custom-made chips for the applications. Regional institutions, networks and programmes could concentrate, in particular, on the training aspects of both software and hardware applications, provide for a harmonization of policies and promote possible regional or subregional manufacturing facilities. In addition, the regional programmes could cover the entire field of electronics, while the international centre could concern itself specifically with the high technology area of micro-electronics. The UNIDO secretariat is engaged in elaborating, in consultation with interested Governments, an integrated set of international and regional initiatives to strengthen the technological capabilities of developing countries and provide momentum to their efforts in this area.

106. As regards research on energy from biomass, data collected by the UNIDO secretariat revealed that in 1982 there were at least 60 research institutes in 31 developing countries engaged in research and development on the industrial conversion of biomass. The 1981 budget for this research and development was said to be 12 million dollars, and over 500 professionals were reported to be working in this field. The Forum agreed that a network of these institutions that could synergize research and development activities, permit testing and field experiments and in particular the scaling up of the technology as necessary, would have great potential. It is therefore proposed to create a network on the industrial conversion of biomass involving institutions in both developed and developing countries. 41/

107. In view of the fact that research and development institutions in several developing countries are engaged in solar energy research and also that several developing countries have to take decisions concerning the application of solar energy equipment supplied by developed countries, the establishment of a consultative group for solar energy research and application is considered beneficial for promoting co-operation among research and development institutions and strengthening the capabilities of participating developing countries. 42/ The UNIDO secretariat has already identified several research and development institutes in developing countries.

108. The field of materials is vast and diverse but at the same time important from the point of view of natural resources as well as international competitiveness. Generally speaking, developing countries may have to formulate policies in regard to selected important materials in accordance with their actual needs, priorities and conditions. To help developing countries and provide them with the necessary technological intelligence, it has been proposed to examine the feasibility of establishing an international mechanism or network, as suggested by the Forum (ID/WG.389/6, para. 52).

4. Technologies for humanity

109. The Forum recommended that a new form of international co-operation should be considered, with the designation of a limited number of new advanced technologies to meet particular needs of clear urgency to the human community as "technologies for humanity" (ibid., para. 22). These technologies should be developed and disseminated in the public domain. "Technologies for humanity" should be clearly and precisely defined, so that international efforts can be focused on specific problems until appropriate solutions are found and effectively disseminated throughout the world, especially in developing countries. All nations able to contribute to the development of these technologies should be encouraged to do so. Commonly funded programmes for such technologies for humanity could make it possible to disseminate the fruits of modern science and technology so as to improve the quality of life of humanity at large. Such a move would reinforce the commonly held aspiration that the human being must be the centre of concern in technological development.

5. International roster of scientists and technologists

110. The Forum recommended that UNIDO, together with the United Nations Educational, Scientific and Cultural Organization (UNESCO) and other international organizations, should continue to mobilize the co-operation of high-level scientists and technologists throughout the world in harnessing the new technologies for the benefit of the developing countries, in particular in the field of industrial development, and should bring the considered views of such experts to the attention of the Fourth General Conference of UNIDO and other relevant forums (ibid., para. 24). Some aspects of this recommendation were further elaborated by the Dubrovnik Workshop, which recommended the establishment of an international roster of scientists and technologists in selected technological advances, who would be willing to assist developing countries through communication, training, field visits or a period of stay in those countries (see ID/WG.401/7). The Workshop recommended that a computerized and updated roster should be developed by UNIDO in implementation of the recommendation made at the International Forum on Technological Advances and Development (see ID/WG.384/6, para. 24). The roster could contain information on the name, qualifications and affiliation of the scientist or technologist, his fields of interest and competence, the countries he is prepared to assist, the period of availability, financial remuneration required etc. Developing countries requiring specific expertise could approach UNIDO, functioning as a clearing house, for information on the basis of which they could contact the expert concerned. The roster could also

be linked to national mechanisms for the utilization of expatriate nationals in their development. UNIDO was requested to establish such a clearing house initially in the fields of micro-electronics, genetic engineering and biotechnology and solar and biomass energy. It was requested to co-operate closely in this matter with UNESCO, the International Council of Scientific Unions (ICSU), the Committee on Science and Technology in Developing Countries (COSTED), the World Association of Industrial Technological Research Organizations (WAITRO) and other relevant organizations. This roster could also be used to mobilize the co-operation of scientists and technologists in the development of applications unique to developing country conditions and in particular in the development of "technologies for humanity".

V. ROLE OF UNIDO

111. The role of UNIDO in strengthening the technological capabilities of developing countries in the 1980s and beyond has already been referred to. The Tbilisi Forum, as well as the expert group meetings in Moscow and at Dubrovnik, have made a series of recommendations on actions to be taken by UNIDO in this respect. A brief review of the role of UNIDO is made below.

112. It may be recalled that Industrial Development Board resolution 47 (XI) on international co-operation in transfer of technology represented a consolidation and restatement of UNIDO mandates in the development and transfer of technology. 43/ The New Delhi Declaration and Plan of Action stressed the need for high priority to the subject and to operational activities and recommended strengthening the institutional arrangements within the secretariat in this field.

113. The contribution that UNIDO could make to the technological development of developing countries stems from the fact that no branch of economic activity influences or is influenced by technology so much as industry. Activities in industrial technology may therefore continue to provide an important motive force for technological development.

114. UNIDO has a unique role to play in assisting developing countries in this respect. It combines a promotional technology programme with substantial technical co-operation activities and a field presence, together with the continuing System of Consultations, where technology transfer and development in the industrial sectors concerned receive particular attention from both developed and developing countries. The technology component is an integral part of most of its technical assistance programmes. In addition, in consonance with the objective of the Vienna Programme of Action on Science and Technology for Development, namely to apply science and technology to development, activities in the field of technology are carried out by UNIDO in juxtaposition with such activities as feasibility studies, investment promotion and the establishment of factories, which are other links in the chain of activities leading to the application of industrial technology for development.

115. Since the Third General Conference, and in line with the high priority accorded by the Industrial Development Board to industrial technology in the follow-up of the Conference, the UNIDO secretariat has undertaken a series of activities, 44/ such as the programme on technological advances; assistance to policy formulation at the national level; technological advisory services; strengthening of TIES; programmes of technological co-operation between small and medium enterprises; a mini-hydro programme; consolidation and streamlining of the Industrial and Technological Information Bank (INTIB); technical assistance projects in appropriate and advanced technologies and institutional infrastructure; implementation of several important projects financed by the United Nations Financing System for Science and Technology for Development; and finally development of instruments for negotiations in technology matters, such as model contracts, under the auspices of the System of Consultation.

New role for UNIDO

116. As has been emphasized in the Forum and at other meetings, the emergence of technological advances and the need for developing countries to respond to them places important additional responsibilities on UNIDO. These responsibilities should be discharged in order that UNIDO assistance to developing countries can keep up with the changing technological scene and ongoing and anticipated developments in industry. The whole of UNIDO will be involved in this exercise. In its technical assistance programmes, UNIDO, at the request of the developing countries, is already channelling increased assistance to some high-technology areas, such as computer-aided design, silicon and carbon fibre technologies, enzymatic conversion of biomass etc. The technical assistance and other operational programmes of UNIDO will have to be substantially augmented to help developing countries to keep pace with technological change and to create the necessary groups, institutions and structures. The consultation meetings, even though they will be confined to selected industrial sectors, will have increasingly to take note of the impact of technological advance on those sectors.

117. A special responsibility lies with the UNIDO Technology Programme, in particular in relation to its activities concerning technological advances. The Third General Conference and, subsequently, the Industrial Development Board, have already recommended that institutional arrangements within the secretariat should be strengthened in regard to technology, and adequate resources provided. This need has become more urgent in the light of the activities mentioned in paragraph 115 above. The Forum recommended that the UNIDO programme on technological advances (carried out by the Technology Programme) should be expanded and diversified along the lines indicated in the report of the Moscow meeting held in preparation for the Forum (ID/WG.384/16, chap. IV), as well as in its own report (ID/WG.389/6, para. 23).

118. In addition to technical assistance and advisory services, the UNIDO secretariat would have to concern itself with the broad areas of action described below.

1. Stimulating and assisting national action

119. In stimulating and assisting action by developing countries the role of UNIDO could be:

(a) To continue and intensify its monitoring and assessment of technological advances, with particular reference to their impact on industrial development, and to sensitize policy-makers, scientists and technologists and enterprises in developing countries;

(b) To continue to develop a general framework for national action for the 1980s for the developing countries, with special reference to countries at varying levels of development, and help those countries to undertake national examinations based on the general framework. This would be a continuation of the work UNIDO has been doing at the national level. In addition, it would have to assist developing countries on request in the setting up of national groups to monitor and assess technology trends and relate them to national industrial and technological requirements. Studies of technological advances and their trends and sensitization programmes should be continued for these purposes. In regard to technology policies and plans for the 1980s, UNIDO might have to play as active a role as the United Nations system did in the 1950s and 1960s in helping developing countries to establish an overall planning mechanism for development;

(c) To help developing countries, on request, in the setting up of core technical groups and, where necessary, new institutions in selected areas of technological advances as appropriate (ID/WG.401/7, para. 117 (b));

(d) To promote technological capabilities, on request, in several fields of technological advances, including genetic engineering and biotechnology and micro-electronics.* Here special attention may be given to the development of a biomass-based strategy for industrial development and also the promotion of the software industry,** leading to unique applications for developing countries.

2. Strengthening negotiating capabilities

120. The TIES programme would have to be expanded as recommended by the Caracas Plan of Action and should in particular endeavour to ensure the association in it of all interested developing countries and to monitor world technology trends, in particular the changing international technology market

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* The value of production of the electronics industry is put at around $US 200 billion, of which the developing countries may have at best a 5 per cent share. The production of integrated circuits accounts for about $US 15 billion only but the goods in which they are incorporated are far more in value.

** The software industry has an annual growth rate of about 18 per cent.

structure. The secretariat's assistance to developing countries in acquisition policies, its training programmes and manuals and its technological advisory services would have to be strengthened in order to focus increasingly on areas of technological advances.*

3. Co-operation among small and medium-sized enterprises

121. As a means of enlarging technological options, the secretariat would have to expand its ongoing programmes for the promotion of technological co-operation in small and medium-sized industries and the improvement of technology delivery systems in developing countries. Special attention might have to be given to the promotion of such co-operation in high technology areas and the establishment of innovative small firms in developing countries.

4. Energy-related technologies

122. In view of the implications of energy for industrial development, the secretariat would have to intensify its efforts to identify and promote the development and use of energy-related technologies and the necessary equipment.

5. Promotion of international co-operation

123. The secretariat would have to take new initiatives in international co-operation, including the promotion of regional and subregional action in the following areas:

(a) Promoting a forecasting and assessment network among developing countries;

(b) Promoting or examining the possibility of setting up international centres or other mechanisms to strengthen the capabilities of developing countries in selected technological advances in accordance with identified needs and requirements of developing countries;

(c) Elaborating and implementing the concept of "technologies for humanity";

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* The Seventh Meeting of Heads of Technology Transfer Registries, held at New Delhi from 7 to 10 December 1982, gave preliminary consideration to some of these matters, including a secretariat paper on the licensing of software (ID/WG.383/3) and decided to pursue them further at future meetings (see ID/WG.383/8, para. 3). At a meeting of selected heads of technology transfer registries in July 1983, a detailed outline was evolved for the monitoring of global technology transfer trends by members of TIES.

(d) Developing and operating an international roster of high level scientists and technologists;

(e) Organizing and making available to interested developing countries a travelling exhibition of the application of technological advances for development;*

(f) Continuing to mobilize the interest and efforts of policy-makers and members of the scientific and technological community and industry on a world-wide scale;

(g) Examining and pursuing new initiatives for technological co-operation among developing countries (e.g. consultancy consortia and an international network mechanism for technology exports).

6. Technological information

124. UNIDO industrial and technological information activities would need to be considerably strengthened in order to enhance the capabilities of developing countries in the selection and acquisition of technology. As already reported to the Industrial Development Board, INTIB would require additional resources for discharging the responsibilities already entrusted to it. 45/ In addition, INTIB would have the further responsibility of helping developing countries to handle and process technological information in an era characterized by the "information explosion". In the sectors already covered by INTIB, special attention would have to be given to information concerning the application of new technologies, including energy-related technologies, which would improve or affect the performance of those sectors. In addition, information on selected technological advances, their applications and their impact on the international technology market would have to be collected and disseminated.**

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* It was suggested at the Forum that an exhibition of this type might be organized for the Fourth General Conference (see ID/WG.389/6, para. 84), but lack of time and money might make this impracticable.

** A beginning has been made with "monitors" on micro-electronics, genetic engineering and biotechnology, and materials. But as indicated at the Tbilisi Forum and the Moscow and Dubrovnik meetings, these efforts have to be intensified.

7. Co-operation and co-ordination

125. In discharging these responsibilities, the UNIDO secretariat would continue to co-operate with all relevant international organizations, bearing in mind the Vienna Programme of Action and other relevant international declarations and pronouncements concerning technology. As a result of discussions within the framework of the Administrative Committee on Co-ordination (ACC), UNIDO would be participating in a number of joint projects with other international organizations. In addition, the UNIDO secretariat acted as the Chairman of Working Group I of the ACC Task Force on Science and Technology for Development, which dealt with early identification and assessment of scientific and technological developments and a global network of scientific and technological information. UNIDO will continue to make available to other international organizations, including the regional commissions and technology transfer centres, the experience and information acquired in this field while drawing equally upon the work done by those organizations in their areas of competence. As the central co-ordinating agency in the field of industrial development, UNIDO is also responsible for ensuring co-ordinated efforts in the application of industrial technology in the further industrial and economic development of the developing countries.

Notes

1/ See the Lima Declaration and Plan of Action on Industrial Development and Co-operation (A/10112, chap. IV), resolution 2 of the Second General Conference, on the selection of appropriate industrial technology (ibid., chap. V, para. 292) and Industrial Development Board resolution 47 (XI), on international co-operation in the transfer of technology (Official Records of the General Assembly, Thirty-second Session, Supplement No. 16 (A/32/16), annex I).

2/ See the section on industrial technology of the New Delhi Declaration and Plan of Action on Industrialization of Developing Countries and International Co-operation for their Industrial Development (ID/CONF.4/22 and Corr.1, chap. VI, sect. III).

3/ See Report of the United Nations Conference on Science and Technology for Development, Vienna, 20-31 August 1979 (United Nations publication, Sales No. E.79.I.21 and corrigendum), annex IV, para. 20.

4/ See "Strengthening of scientific and technological capacities for industrial development in the developing countries", report submitted to the High-Level Expert Group Meeting on Industrial Development Strategies and Policies for Developing Countries, held at Lima from 18 to 22 April 1983 (ID/WG.391/10), p. 9.

5/ "Monitoring progress made in accelerating industrialization in the developing countries: third survey, 1981-1982" (UNIDO/IS.370), pp. 58-72.

6/ For a list of 42 developing countries and some 150 research institutes, see Directory of Industrial and Technological Research Institutes (UNIDO/IS.275).

7/ See, for example, Technologies from Developing Countries, Development and Transfer of Technology Series No. 7 (vols. I and II).

8/ For a report on the review, see ID/B/C.3/86 and Add.1 and 2.

9/ To be published. See also Technology Exports from Developing Countries, vol. I, Argentina and Portugal, Development and Transfer of Technology Series No. 17.

10/ For a classification of occupational categories and the variety of human resource skills required for industrialization, see the report of the High-Level Expert Group Meeting on Accelerated Development of Human Resources for Industrial Development (ID/WG.394/8).

11/ For details, see "Monitoring progress made in accelerating industrialization in the developing countries: third survey, 1981-1982" (UNIDO/IS.370), pp. 60-61.

12/ For consultancy and advisory services see also "Strengthening of scientific and technological capacities for industrial development in developing countries" (ID/WG.391/10), pp. 27-36.

13/ The technological alternatives were examined in some detail in the 1978 International Forum on Appropriate Industrial Technology. (See Monographs on Appropriate Industrial Technology, Nos. 1-12.)

14/ For a description of the activities carried out, see "UNIDO's Programme of Technological Advances" (UNIDO/IS.411).

15/ For a detailed discussion of the impact of industry, see the issue paper for the Forum entitled "Technological advances and development: a survey of dimensions, issues and possible responses" (ID/WG.389/3), paras. 66-84.

16/ See "Policy responses to technological advances: some illustrative cases" (ID/WG.384/3/Rev.1).

17/ For details, see the section on technological advances in the bibliography of UNIDO documents relating to the transfer of technology (UNIDO/IS.228/Add.1/Rev.1).

18/ See "Potential aplications of space-related technologies to developing countries", background paper submitted by UNIDO to the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (A/CONF.101/BP/IGO/13).

19/ See the reports of the International Forum on Technological Advances and Development (ID/WG.389/6) and the High-Level Expert Group Meeting on Industrial Co-operation among Developing Countries, held preparatory to the Fourth General Conference of UNIDO (ID/WG.399/4).

20/ See "Co-operative programme of action on appropriate industrial technology" (ID/B/188).

21/ See "Integrated application of emerging and traditional technologies for development: report of the Ad Hoc Panel of the Advisory Committee on Science and Technology for Development" (International Rice Research Institute, 1982).

22/ One such system is described in a concept paper on the Technology Services Delivery System (TSDS), based on the experience of the Philippines (ID/WG.350/1).

23/ See "First global study on the capital goods industry: strategies for development" (ID/WG.342/3).

24/ The subject of restructuring is dealt with in detail in the documentation submitted under agenda items 4 (ID/CONF.5/14) and 5(e) (ID/CONF.5/3).

25/ See "Methodological problems of a comprehensive programme of scientific and technological progress in the Soviet Union: a preliminary note", by Academician J.M. Gvishiani (ID/WG.384/15).

26/ For some examples, see "Monitoring progress made in accelerating industrialization in the developing countries: third survey, 1981-1982" (UNIDO/IS.370), p. 63.

27/ See the report of the High-Level Expert Group Meeting on the Accelerated Development of Human Resources for Industrial Development, held preparatory to the Fourth General Conference of UNIDO (ID/WG.394/8).

28/ See also "Micro-electronics and developing countries: towards an action-oriented approach" (ID/WG.384/5/Rev.1). For software, see "Problems of software development in developing countries" (UNIDO/IS.383).

29/ See "Problems of software development in developing countries" (UNIDO/IS.383).

30/ See "Genetic engineering and biotechnology and developing countries: directions of action" (ID/WG.384/4/Rev.1) and "Implications of biomass energy technology for developing countries" (ID/WG.384/6/Rev.1).

31/ See "Implications of new materials and technology for developing countries" (ID/WG.384/1/Rev.1).

32/ World Plan of Action for the Application of Science and Technology to Development (United Nations publication, Sales No. E.71.II.A.18), chap. V, p. 39.

33/ Report of the United Nations Conference on Science and Technology for Development Vienna, 20-31 August 1979 (United Nations publication, Sales No. E.79.I.21 and corrigendum), chap. I.

34/ See "Overview of selected problems of technology transfer to developing countries" (ID/WG.388/1), p. 4.

35/ See "UNIDO model form of turnkey lump-sum contract for the construction of a fertilizer plant" (UNIDO/PC.25) and "UNIDO model form of cost-reimbursable contract for the construction of a fertilizer plant" (UNIDO/PC.26).

36/ See also the report of the High-Level Expert Group Meeting on Industrial Co-operation among Developing Countries held preparatory to the Fourth General Conference of UNIDO (ID/WG.399/4).

37/ Report of the United Nations Conference on Technical Co-operation among Developing Countries, Buenos Aires, 30 August-12 September 1978 (United Nations publication, Sales No. E.78.II.A.11 and corrigendum), chap. I.

38/ International competition in advanced technology: Decisions for America, Washington, D.C. (National Academy Press, 1983), p. 32.

39/ See the statutes of the International Centre for Genetic Engineering and Biotechnology (ID/WG.397/8) and the resolutions of the Ministerial-level Plenipotentiary Meeting on the Establishment of the Centre, held at Madrid from 7 to 13 September 1983 (ID/WG.397/9).

40/ Report of the Expert Group Meeting on Implications of Micro-electronics for the ECLA Region (ID/WG.372/17).

41/ See also "Implications of biomass energy technologies for developing countries" (ID/WG.384/6/Rev.1) and "Directory of industrial and technological research institutes: industrial conversion of biomass" (UNIDO/IS.372).

42/ For more details, see "Emerging photovoltaic technologies: implications for developing countries" (ID/WG.384/2).

43/ See Official Records of the General Assembly, Thirty-second Session, Supplement No. 16 (A/32/16), annex I.

44/ For more details, see the annual reports of the Executive Director for 1980, 1981 and 1982 and various reports to the Board (ID/B/241, ID/B/242, ID/B/252. ID/B/259 and ID/B/281).

45/ See the reports to the Board contained in documents ID/B/241, ID/B/259 and ID/B/281. See also the decisions of the Board at its fourteenth, fifteenth and sixteenth sessions (Official Records of the General Assembly, Thirth-fifth Session, Supplement No. 16 (A/35/16); ibid., Thirty-sixth Session, Supplement No. 16 (A/36/16); and ibid., Thirty-seventh Session, Supplement No. 16 (A/37/16).