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DEVELOPMENT AND TRANSFER OF TECHNOLOGY
INCLUDING THE INDUSTRIAL AND TECHNOLOGICAL INFORMATION BANK

Report by the Executive Director

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Summary

Analyses the activities undertaken by the secretariat during 1984 in the field of development and transfer of technology (including the role of the Industrial and Technological Information Bank) against the general thematic background of industrial technology for the 1980s. Reviews the actions taken by developing countries in the context of the global technology scene and discusses some considerations for future action. Supplements information contained in the Annual Report of the Executive Director, 1984 (ID/B/340) by reviewing activities implemented towards the end of the year.

Introduction

1. The Industrial Development Board at its eighteenth session considered the Report of the Executive Director on "Development and transfer of technology including the Industrial and Technological Information Bank" (ID/B/318). In its conclusion 1984/5[1/] the Board reiterated the high priority that it attached to the development and transfer of technology to developing countries and, among other things, requested the Executive Director to submit to its nineteenth session a report on the subject.

2. Detailed information on the activities of the Technology Programme in 1984 including information on the work of the Industrial and Technological Information Bank (INTIB) is contained in the Annual Report of the Executive Director, 1984 (ID/B/340, chap. V, paras. 77 - 118)). Following the approach adopted in the past, the present report makes a thematic analysis of some aspects of the overall trends and issues of industrial technology for the 1980s within which perspective the UNIDO activities need to be viewed.

3. The issues presented to the fifteenth, sixteenth and seventeenth sessions of the Board resulted in a synthesis in the secretariat's documentation to the Fourth General Conference of UNIDO and in several recommendations by the Conference which have been briefly analysed in the Annual Report of the Executive Director, 1984. The report to the fifteenth session of the Board (ID/B/252) analysed the ongoing efforts of the developing countries in the field of industrial technology and identified the problem areas while the report submitted to the sixteenth session (ID/B/281) drew attention to the emerging technological advances and the policy responses needed. The report to the seventeenth session (ID/B/296) combined the trend of thought in the two previous reports in order to develop the elements of an overall policy framework and highlighted the need for integration of industrial and technology policies. It would be appropriate and useful if, in the report to the nineteenth session, attempts by developing countries to develop a framework for national action in the field of industrial technology were placed in the context of the global technological scene to provide the necessary perspective for their efforts. The present report therefore addresses itself to the following broad questions, it being understood that in a few pages and with limited resources exhaustive analysis is not possible: What is the global technological scene and its implications in particular for industry? What actions are the developing countries at different levels of development taking in this respect? What considerations emerge for future action? Since detailed documentation was submitted to the Fourth General Conference held in August 1984, the discussion will be brief, and references will only be made to ongoing activities of UNIDO.[*/]

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*/ A mid-decade review of the implementation of the Vienna Programme of Action with special reference to industrial technology was also made by the secretariat as an contribution to a report compiled by the United Nations Centre for Science and Technology for Development.

I. TRENDS IN THE GLOBAL TECHNOLOGY SCENE

4. The convergence of technological advances has been the most remarkable feature of the technological scene in the current decade. First, most of the technological advances have applications over a wide range of economic sectors. Most of the areas in which the advances are taking place are by now well known, such as microelectronics, genetic engineering and biotechnology, telecommunications, solar energy, optical fibres and new materials. Secondly, the growing possibilities of cross-fertilization of technologies and their conversion into industrial opportunities have led to a remarkable and accelerated interaction between technological advances. The interaction between microelectronics and telecommunications is well-known and perhaps the most significant. Biotechnology is benefiting from information technology for example with regard to molecular graphics, nucleotide synthesis and the field of bioinformatics in general. Biotechnology is contributing to microelectronics in attempts to develop bio-chips and new materials in the area of bio-polymers. Research into new materials has spurred on developments in electronics and opto-electronics and telecommunications. Thirdly, the impact on a wide range of industrial sectors continues to be significant, limited only by the receptiveness of industrial establishments and their capacity to undertake fresh investments. One overall impact is the introduction of new concepts of "factory of the future" in two respects: factory automation and robotization in the engineering industries in developed countries and microbes functioning as factories in the chemical industries. Fourth, spread across all these developments is the consideration of energy saving, which is facilitated significantly by some of the technological advances. Far more attention in recent years than in the past has been accorded to energy conservation in industry as well as minimizing the energy-intensity of industrial processes and materials. Fifth, within each industrial sector, technological changes not related to technological advances continue to take place.

5. In spite of the general economic recession, the growth in expenditure on research and development (R and D) in the area of technological advances has been quite rapid in the industrialized countries. This is particularly evident in the fields of microelectronics, genetic engineering and biotechnology and solar energy. In almost every aspect of microelectronics and information technology, research and development have been intensified to include such areas as the use of gallium arsenide instead of silicon for chips, increasing chip capacity and operating speeds, improvement of processes for fabrication of chips and new approaches to transducers. Some 10 per cent of sales is being reinvested in R and D. In the field of genetic engineering and biotechnology, recent and ongoing R and D efforts span improvement of basic science and methodology (including better understanding of animal and plant cells), human medicine (e.g. vaccines for infectious diseases, diagnostic agents and drug delivery systems), agriculture (e.g. nitrogen fixation, plant tissue culture, biological pesticides and livestock improvement) and industrial microbiology (e.g. biomass conversion, lignocellulosic degradation, bioreactors and fermentation and scaling-up problems). In the case of solar cells, the work in regard to amorphous silicon solar cells has proceeded rapidly in recent years. Partly as a result of technological advances there is greater

emphasis on basic research and more collaboration of universities and academic institutions with industry, sometimes raising issues of openness of academic research.

6. The impact of technological advances has been felt on intra-industry R and D in several industrial sectors. Taking the United States of America as an important example, R and D expenditure is expected to grow at a rate of over 10 per cent in machinery, electrical and communication equipment, chemicals and instrumentation. In almost every industry (e.g. instruments, automobile and iron and steel industry) more R and D investment is made for new products or improving existing products than for development of new process technology (except in the case of paper and pulp). Emphasis on improvement of existing products is also significant in such fields as non-ferrous metals, chemicals, rubber and food and beverages.[2/]

7. As regards production trends, in spite of the general economic recession, the telecommunications industry and the information technology industry in general have registered significant increases. The semiconductor sector has continued to grow rapidly in spite of some set-backs. The software sector has exhibited a consistently high growth rate. In the field of genetic engineering and biotechnology, new products on account of genetic engineering are still limited but the potential is considered very high as seen from the subscriptions to new ventures - which have somewhat abated recently - and the growing interest of large companies. There has also been a significant increase in the production of solar cells, including the introduction of amorphous silicon in consumer applications.

8. Attention has been drawn in the past to the changing international technology market.[3/] There has been close interaction between computer firms, semiconductor firms and telecommunications firms with regard to microelectronics and telecommunications in general. A certain amount of vertical integration in the semi-conductor industry is also taking place alongside a trend towards concentration and specialization by several firms. A polarization of the industry is developing, with a small number of high volume producers and the remainder involved in specialized products which are only required in a small volume. In the United States of America, technological and market developments are expected to result in a reorganization of the computer and software industries. The telecommunications industry has been diversified and opened up. In the optical fibre/cable market, the majority of suppliers are vertically integrated and market entry is difficult. In the United States of America, 90 per cent of fibre/cable shipments have been supplied by only five companies in recent years. There have, however, been some important new entrants into the fibre-optics market.

9. With regard to biotechnology, chemical, oil and food processing corporations have demonstrated their interest in a number of ways, including acquisition of shares in other firms and research grants to universities. Although in the United States of America some 200 small firms have done pioneering work in biotechnology, the role of the giant corporations is growing in importance. The oil corporations have shown particular interest in solar energy,

resulting in mergers, take-overs and intercorporate investments. There has also been a trend recently towards giant corporations trying to diversify into several new and sometimes unrelated technological fields. There has also been a significant trend by several big chemical companies to spread their activities to cover germ plasms, seeds and other agro-business.[4/] Another trend is the formation of associations of companies in semiconductor and biotechnology in the United States of America and Japan.

10. The patterns of international technology transfer in the area of technological advances reveal considerable flexibility sometimes involving technology and market "swaps". This is particularly true in recent advances in biotechnology where, as of 1983, at least 50 enterprise-level agreements had been drawn up for international transfer of technology.[5/] In a majority of them Japan figures as the recipient and the United States of America as the transfer or, while Germany, Federal Republic of, Italy, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland are also involved. In one instance a firm in Malaysia entered into an agreement with a research company in the United States of America in the field of plant genetics. The products involved in these transfers are monoclonal antibodies, interferons and, to a lesser extent, hepatitis-B vaccine and insulin. The mechanisms used include subsidiaries, equity investment, joint ventures, licensing and other agreements. The objectives of joint ventures cover joint research and development, joint development involving complementary inputs from the two parties and marketing. Other agreements are concerned with funding R and D in exchange for access to technology or right to later production and marketing; research co-operation; exchange of clinical test drug technology; marketing rights within a country or outside; agency arrangements; and supplies of commercial quantities of biochemicals. In one case there is a tie-up between an electronics firm, specializing in application of microelectronics to biotechnology and a trading company.

11. Perhaps the most important impact of the technological advances has been on industry. While the potential of such impact is much greater, actual changes take place as and when market and cost considerations permit. The impact has, however, already been felt over a wide range of industrial sectors. Applications of microelectronics reported include, for example, a management information system for the paper industry; chemical process controls; control of temperature in glass furnaces; computer controlled flame cutters; and applications in the textile and garment industry, the footwear industry and meat processing. Although the impact of genetic engineering and biotechnology has been initially in the pharmaceuticals sector, applications in the fields of animal vaccines and agriculture are expected to follow. Commercialization plans of several companies in the United States of America and Japan reveal the following: insulin, enzymes for wine production (1985); bovine growth hormones (1986); foot and mouth disease vaccine (1987); animal growth hormones, blood fractions (1988); and interferons, vaccines, various drugs, pharmaceuticals and chemicals, agricultural chemicals, tree seeds, diagnostic reagents, yeast production, improved alcohol production (1985-1990).[6/]

12. Apart from the impact on individual industrial sectors, the concept of the factory itself is changing as a result of innovations such as computer-aided design and computer-aided manufacture in addition to robotics and flexible manufacturing systems (a combination of machine tools and other equipment such as robots under central on-line computer control in an automated factory system). The concept of economies of scale is in some respects giving place to the concept of economies of scope. Products to which flexible manufacturing systems have been applied in Japan include diesel engines, machine tools, compressors and pumps and valves. It is, however, thought that considerations of investment and cost of production and lack of availability of the needed combination of expertise currently limit the applications of flexible manufacturing systems. For the present, those systems are filling a niche in engineering and capital goods industries between fixed automation systems used for high volume production and stand-alone machine tools.7/

13. There has been greater awareness of the need and urgency for adoption of standards in microelectronics, software and telecommunications. The patentability of software and of micro-organisms has received attention in several developed countries. The question of adopting safety guidelines for research in genetic engineering and biotechnology has also received attention from some Governments. Recent industrial accidents, in particular the one at Bhopal (India), have highlighted the need for greater attention to plant safety, particularly in hazardous industries, including the possibility of formulating relevant guidelines for transfer of technology. A register of potentially toxic chemicals is kept by the United Nations Environment Programme.

14. During the past years, government intervention to build a capability in technological advances has been noticeable in several industrialized countries.8/ Particular emphasis has been laid on the importance of innovation and the need to keep a competitive edge in international trade. Public funding of R an D in the field of technological advances has been stepped up in several countries. Comprehensive policies have also been introduced with regard to information technology in countries such as Ireland and the United Kingdom. Innovative arrangements - technology parks and special corporations in the fields of technological advances, for example - have been established in the United Kingdom, Canada and several states of the United States of America. Co-operative programmes of R and D supported by Governments in Europe include the FAST (Forecasting and Assessment of Science and Technology) and ESPRIT (European Strategic Programme for Research and Development in Information Technology) programmes of the European Economic Community.

15. A few applications of microelectronics for development were identified, inter alia, at a meeting of selected institutions involved in the application of information technology for development convened by the secretariat in March 1984.9/ These include: applications in India and Senegal of computers for schools; applications for health care in Mali; development of an electronic load controller for mini-hydro equipment; microprocessors for food grain drying; and application of microcomputers for agricultural management and for analysis of wind data and modelling of windmills. In an attempt to bring

together interested institutions and to promote such work, the meeting recommended the establishment of a consultative group on information technology. As regards biotechology, it offers great potentialities for development in the food, fodder, fuel and fertilizer sectors.[10/] Once the International Centre for Genetic Engineering and Biotechnology is operational, it is expected to open new possibilities of the application of genetic engineering and biotechnology for development.

16. Technological change has also been affecting international trade in several commodities in particular through the emergence of substitutes. A number of intra-industry technological changes have also taken place in recent years. Two examples of this are the palm oil and sugar industry. Palm oil is mainly produced by a small group of developing countries and serves as an economically viable edible oil as well as an industrial raw material. Cloning of the oil palm by tissue culture has been successfully carried out and commercial exploitation of this technology is expected shortly. Genetic modification, if carried out, will also permit readjustments of the fatty acid composition of the oil which could have a profound influence on the edible oil industry and also on the oleo-chemical industry. With regard to sugar produced from sugar cane the emergence of natural and synthetic sweeteners and high fructose syrup as a substitute has had a major impact on the sugar industry with the result that traditional sugar producing countries are facing considerable difficulties in marketing sugar. Thus, other avenues have to be sought for the utilization of sugar cane. Simple sugars can be converted through fermentation into different chemicals such as acetic acid and acetone, and Brazil has embarked on a long-term plan for a sucrochemical industry including the establishment of a centre which will be responsible for an integrated approach to the use of carbon from biomass in the production of fine chemicals.[11/]

17. Technological changes are also taking place in the petrochemicals industry, in particular in processes which employ feedstocks from developing countries that are becoming more prominent in the world market such as natural gas and methanol. Zeolite chemistry, now in advanced developmental stage, carries the potential to convert synthesis gas (from natural gas) and methanol directly to olefins, ethylene and propylene which are the prime intermediates for practically all plastics. Leading chemical corporations are expecting methanol, first, and synthesis gas, later, to be the feedstocks for the new petrochemical plants of the 1990s. Research in liquefaction and gasification of coal has also been proceeding rapidly in recent years. Application of research results is expected within a decade in the field of superconductors, which could revolutionize the technology of generating, transmitting and consuming electrical energy.

II. ACTIONS BY DEVELOPING COUNTRIES

18. In this chapter a discussion of actions taken by some of the developing countries in response to technological advances is followed by an analysis of information received by

the UNIDO secretariat on the actions taken by many developing countries in the field of development and transfer of technology as a whole. In view of the vast and diverse nature of the subject, the actions described here briefly should be taken as indicative rather than comprehensive.

19. In the field of microelectronics and information technology in general, facilities for manufacture or packaging of integrated circuits have been established in several countries including India, Iraq, Malaysia, the Philippines, and the Republic of Korea, mainly as off-shore production facilities for export purposes. (The tendency for increase in off-shore production arrangements would appear to have more or less stopped in recent years as a result of the trend towards vertical integration in semiconductor companies.) Several countries have also developed the capability for design and/or manufacture of hybrid circuits. Peripherals and accessories are manufactured in several developing countries. In the Republic of Korea, the microelectronics industry has been growing at an annual rate of over 30 per cent in the last decade, and the industry is now considered as a strategic industry with high priority.[12/] In recent years Mexico and notably Brazil have registered considerable progress in the assembly of micro-computers.In the case of Brazil which has established a National Institute of Electronics, a policy of reservation of the field of microcomputers for local industry has apparently contributed to the growth of local production. India has recently liberalized the restrictions on local manufacture of micro- and mini-computers, at the same time enabling users to obtain computers to their requirements either from indigenous sources or from abroad. Several countries in Latin America are implementing informatics policies covering in particular purchases of computers for public organizations. In view of the interest expressed by Latin American countries in regional co-operation in microelectronics the secretariat is organizing a meeting to take place in June 1985 in Caracas (Venezuela) to initiate a regional network of microelectronics for Latin America and the Caribbean. A UNIDO-sponsored mission in connection with the ECWA/UNIDO Meeting on microelectronics held in March 1984 revealed that many activities relating to informatics are taking place in Arab countries. Special problems have been identified such as the "arabization" of computers in which there is considerable interest in the region. The potentialities of microelectronics applications and the feasibility of a silicon foundry for the region are also being studied.

20. Software capabilities are being built up in a number of developing countries, a few of which have started to export software. In China, UNIDO provided assistance in the establishment of a micro-computer laboratory and in software training. Singapore has formulated a wide-ranging set of policies to acquire a capability in information technology. Potentiality for development of a computer software industry also exists in a number of other developing countries such as Argentina, Brazil, Egypt, India, Malaysia, Mexico, Republic of Korea, and Venezuela.

21. At the other end of the spectrum are developing countries where electronics activities are confined to consumer electronics or to the few existing electrical industries. For these countries which are at an early stage of development there is nevertheless a need for the introduction of policies for the acquisition of computers and other electronics equipment, in accordance with the socio-economic needs of the country concerned. To this end, the secretariat helped the Government of Kenya in organizing a national seminar on microelectronics and software held in February 1985 in Nairobi, as a result of which several national level actions are expected to be undertaken. Representatives were also invited to the meeting from Ethiopia, Sudan, Uganda, United Republic of Tanzania and Zambia. The concept of regional networking has met with widespread interest in almost all the developing regions.

22. Developing countries have not progressed in the field of microelectronics at an even pace. While a few countries would appear to have acquired a basic capability in terms of manufacture or design of semiconductors, several possess manufacturing facilities of an assembly type. Most developing countries have, however, expressed a strong interest in acquiring capabilities in the design of integrated circuits, which will enable them to design those applications most appropriate to their needs. Another related capability of importance is the capacity for systems analysis and systems building. In this connection it is interesting to note that the Government of Mexico has established a systems company in the parastatal sector to respond in particular to the needs of major public utilities; the necessary hardware is being obtained from abroad.

23. In the case of genetic engineering and biotechnology, national centres have been established or are being established in several countries such as Brazil, India, Mexico and Thailand. National co-ordinating committees for biotechnology have also been set up in India, Kuwait and Venezuela. Proposals have been received from Algeria, Argentina, Bulgaria, Chile, China, Cuba, Egypt, Greece, Indonesia, Mexico, Venezuela, Yugoslavia and Zaire to affiliate their national institutions or networks with the International Centre for Genetic Engineering and Biotechnology. Other countries at an earlier stage of development have signed the statutes of the International Centre, demonstrating their interest in modern biotechnology. Efforts at regional networking are under way in Latin America and a conference on biotechnology for development for Arab countries is planned for May 1985.

24. Awareness of the importance of technological advances has been evident in all developing regions. In Africa, an expert group meeting on the implications of new technologies for the implementation of the Lagos Plan of Action and the programme for the Industrial Development Decade for Africa, held in Mbabane (Swaziland), in October 1984, recommended that each African country should set up core groups of experts, within existing competent institutions or university departments, to provide nuclei for developing the country's "intelligence capacity" on genetic engineering and biotechnology as well as microelectronics.[13/]

25. Thus, the process of policy response to technological advances has commenced in some developing countries, and requests to UNIDO for technical assistance are on the increase. In order to acquire a technological capability in areas of technological advances, most developing countries have to re-orient and strengthen their existing efforts in the field of technology as a whole. In this connection, it is particularly important to undertake a periodical review of their ongoing efforts to develop a framework for national action in the field of industrial technology. This would be facilitated by an analysis of the information obtained from a number of developing countries in response to a questionnaire issued by the secretariat as part of its efforts to monitor the progress made in accelerating industrialization in developing countries.[14/] The information reflects the perceptions and intentions of Governments and shows clearly that parallel to the small measure of policy response to the changing technological scene, many developing countries are engaged in increasingly coherent measures to strengthen their technological capabilities.

26. Conscious efforts have been made by developing countries at different levels of development to formulate explicit policies or plans or create institutional arrangements. Countries such as Ethiopia, Guatemala, India and the Republic of Korea have already formulated explicit technology policies and plans, while in Sri Lanka a science and technology policy is under formulation. The secretariat provided expert advice to the Government of Sri Lanka in a national workshop on science and technology policies held in March 1985. Without as yet the formulation of explicit policies, national councils of science and technology or similar institutions have been established in many developing countries, including Bangladesh, Cameroon, Costa Rica, Indonesia, Kenya, Malawi, Malaysia, Mexico, Pakistan, Peru, Singapore, Sudan, Thailand, Uruguay and Venezuela. State commissions and committees have been established in China and Mongolia. Greater attention to research and development has been noticed in some countries: Mexico has allocated approximately one per cent of its annual GNP to R + D, while this figure is expected to reach two per cent in the Republic of Korea by 1986, and Chile has established a national fund for science and technology. Burundi, Mali and Pakistan have recognized the need for appropriate technologies suitable to their conditions. In Sudan, a study was undertaken on the development of technology and energy in the country until the year 2000. It is important to note that the countries mentioned above are at different levels of development.

27. The trend in technology acquisition is for more and more countries to establish technology transfer registries or other mechanisms to monitor and screen technology imports. Increasing interest is being shown in the Technological Information Exchange System (TIES) as well as in regional activities within the System. While the screening of technology imports started with some of the relatively advanced developing countries now other countries have also established such mechanisms. Bolivia, Ecuador, Ethiopia, Panama, Sri Lanka, Turkey and Yugoslavia have initiated measures of different types that aim at monitoring and evaluating technology imports. Guatemala has established a transfer of technology unit within the Ministry of Economy and the services of a consultant are expected to be made available

shortly by UNIDO to help define its programme of work. Similar units are planned in Burundi and Pakistan.

28. The problems faced by developing countries in the area of research and development have been discussed in document ID/B/281 which was submitted to the Board at its sixteenth session. The trend of replies to the questionnaire sent out by the secretariat shows that in several countries, such as Ethiopia, Lesotho, Malawi, Pakistan and Rwanda there is an emphasis on the utilization of local resources and the development of appropriate technologies. In the Sudan, expert advice was provided by the secretariat on mechanisms to promote commercialization of technologies developed locally. With a view to accelerating the transfer of research results, some countries are undertaking measures such as the establishment of a fund to provide loans and risk capital for development projects and insurance systems to guarantee return on new domestic products and processes. Measures initiated or planned in some developing countries include preferential treatment in the approval of industries to be set up with new domestic processes and encouragement to the public sector to devote more attention to research and development. The importance of scientific and technological education is also gaining recognition.

29. Importance has been attributed in many developing countries to industrial and technological information. Information centres have been created either as separate institutions or as part of ministries or industrial research institutions, or, in a few instances, as part of a chamber of commerce. In certain cases the provision of industrial information is treated as part of industrial or investment promotion and facilities have been established accordingly. Burundi, for example, indicated in reply to the UNIDO secretariat's questionnaire (see para. 25 above) the need for UNIDO assistance in the establishment of a Centre for industrial promotion. Burkina Faso and Oman are among the countries planning to establish industrial information facilities. Existing information facilities in Argentina and India provide information on the availability of local technologies for export to other countries. On the whole, however, developing countries have relied on establishing documentation centres as the main institution in the field of industrial information. But yet adequate progress in industrial development will require processed, problem-oriented and extension-based information.

30. The foregoing analysis is based on replies to the secretariat questionnaire of which less than 50 were received. Although these sometimes lacked detail, they provide a broad idea of the direction in which the countries have been moving. Such information on a continuous basis will help the UNIDO secretariat to adapt its programmes to the efforts of developing countries.

III. SOME CONSIDERATIONS FOR FUTURE ACTION

31. In August 1984, the Fourth General Conference of UNIDO examined the issues of industrial technology in considerable detail. It is therefore not intended that the present report should cover the same ground again but draw attention to some aspects of future action by developing countries in the context of the changing world technological scene and their own ongoing efforts.

32. With the convergence of recent technological advances, the problems of selection and acquisition of technology are becoming more complex. While awareness of all technological developments and new trends is important - particularly to take note of changing patterns of international trade and comparative advantage and to avail of new technological opportunities - selectivity and a careful assessment of the implications of the application of a technology for the conditions and objectives of each individual country are necessary. In fields where technology is rapidly changing and products become obsolete within a few years great care is required on the part of each developing country to decide whether and at which point of time it should apply a technology or enter into production thereof. In certain industries where there is a potentially large market in developing countries - for example solar cells and bio-conversion - there is the risk that suppliers might try to expand their overseas markets to achieve economies of scale with relatively expensive or untested products or processes. Another development which needs watching is the increasing labour-saving nature of the capital equipment that may be produced by industrialized countries in the future. Since most of the capital equipment is imported from industrialized countries, the need to evaluate alternative possibilities of less capital-intensive equipment will become more pressing. In most capital equipment packages the value added by the system as distinguished from the hardware is likely to be considerable. Hence the capacity for disaggregation of those packages and for system-building will also need to be enhanced.

33. In considering policy responses to technological advances it is useful to recall and reiterate the observations of the International Forum on Technological Advances and Development[15/] that high technology cannot be viewed as an escape route from the problems of underdevelopment. Nor can the developing countries follow blindly the high technology path opened by the industrialized countries. A selective and differentiated approach may have to be adopted which will vary according to the conditions and resource endowments of each country, and also according to each technological advance. This would argue for a policy of technological pluralism, where technological advances are selectively integrated, according to the level of development of each country, in its industrial and technological system.

34. It is clear that the developing countries will have to allocate a greater portion of their resources to research and development. As suggested in the documentation to the Fourth General Conference, an increase to one-and-a-half per cent by 1990 and 2 per cent by the year 2000 of their GNP is necessary if they are to acquire a basic capability in the application and assimilation of technological advances. However, the question is not one of a mere percentage increase. Greater attention will have to be paid to the formulation of research priorities and programmes in line with with national needs and objectives and also to strengthening capabilities for evaluation of research projects prior to implementation. Research institutions in several sectors will also have to be reoriented taking into account the impact of technological advances on their specific fields. The creation of new types of technological institutions and transdisciplinary groups may be necessary.

35. The latest advances in science and technology can be applied to meet the most urgent needs of mankind. Work is going on in a number of individual projects but, as recognized by the Fourth General Conference international co-operation in this regard should be encouraged.16/ Three proposals are currently under consideration by the Secretariat for drawing up detailed projects for international co-operation involving existing institutions. The intention is to promote interrelated activities within an overall project which will strengthen existing links among research groups, create new links and ensure a critical mass of effort in attacking a given problem. The problems currently under examination are: protein enrichment of cassava through fermentation, if possible using genetically engineered microorganisms; commercialization of industrial manufacture of technically sound and socially acceptable wood burning stoves; and the use of spirulina algae as human and animal feed. The first of the problems mentioned above has arisen from the fact that cassava - a staple diet in many developing countries, particularly in Africa - has a very low protein content and if the traditional fermentation processes can be improved, considerable nutritive value could be added.17/ Although some work in this field is under way in a few research institutions in developing and developed countries, possibilities such as the use of genetically engineered microorganisms to improve the yields of fermentation have not been explored. Two workshops were held in Vienna in March 1985 to draw up draft international co-operation projects on cassava processing and wood-stoves. The secretariat will pursue the promotion of such projects in its future work in appropriate technology .

36. In the area of industrial information, it is apparent that in many developing countries existing institutions may have to be strengthened, redesigned or reoriented in view of the growing volume of information available and the urgent need for the supply of processed and problem-oriented industrial information. Strengthened capabilities in this field will help developing countries in the design of technological policies, choice of individual projects and avoidance of duplication of research efforts. The services of INTIB can only be effective if national user institutions are strengthened. The strengthening of national institutions and of INTIB has therefore to be pursued as an interactive process.

The many facets of the global technological scene also require that INTIB develop a capability for collection and dissemination of information on the impact of technological change in the various industrial sectors with which it is concerned.

37. It is apparent that a framework for national action for industrial technology in the 1980s is needed irrespective of the stage of development of the developing country concerned. Even countries at an early stage of development will need a minimum programme of essential elements which will strengthen their capacity to handle and assimilate technology. Assistance to African countries to develop such programmes would be particularly useful. It is hoped that as part of the activities related to the Industrial Development Decade for Africa, more national workshops on the formulation of technology policies and programmes will be organized.

38. There is evidently a greater need for the integration of industrial and technology policies, which has not received sufficient attention in the past by most developing countries. Some considerations involved in such integration were indicated in the report (ID/B/318) to the eighteenth session of the Board. It is hoped to further elaborate on those considerations in future reports as part of the overall theme of a framework for national action for industrial technology in the 1980s.

IV. ACTION REQUIRED OF THE INDUSTRIAL DEVELOPMENT BOARD

39. The General Assembly in resolution 39/232 on industrial development co-operation welcomed the decision of the Fourth General Conference of UNIDO to give priority to strengthening the technological capabilities of developing countries. It may be recalled that the Conference in its resolution 2 had affirmed that high priority should be given to industrial technology in the activities of UNIDO.

40. The Industrial Development Board is invited to review the foregoing analysis and take note of the trends in the global technological scene, the ongoing efforts of the developing countries to strengthen their technological capabilities and some of the considerations that emerge for future action. The Board may also wish to reiterate its earlier decisions with regard to the strengthening of institutional arrangements within the secretariat, and the allocation of adequate resources, for the development and transfer of technology.

Notes

1/ Official Records of the General Assembly, Thirty-ninth Session, Supplement No.16 (A/39/16), page 88.

2/ 28th Annual McGraw-Hill Survey of Business: Plans for Research and Development Expenditures, 1983-1986.

3/ See "Technological advances and development: a survey of dimensions, issues and possible responses" (ID/WG.389/3).

4/ Mooney, Pat Roy. "The Law of the seed: another development and plant genetic resources", Development Dialogue (Uppsala, Sweden) 1983, Nos. 1-2, table 24, p.99.

5/ Compiled from: Biobusiness World Data Base: Draft report by United States Government Working Group on Competitive and Transfer Aspects of Biotechnology. Wasnington D.C., McGraw-Hill, 1983.

6/ See Impacts of Applied Genetics. Washington, D.C., Office of Technology Assessment, 1981; and Biobusiness World Data Base, op. cit.

7/ Paul Kinnucan in High Technology, July 1983, quoted in UNIDO's Microelectronics Monitor, No. 10/11, April-September 1984, p. 24.

8/ See "Policy responses to technological advances" (ID/WG.384/3/Rev.1), "Technological advances and development: a survey of dimensions, issues and possible responses" (ID/WG.389/3); "Overview of the microelectronics industry in selected developing countries" (UNIDO/IS.500); and "Elements of some national policies for biotechnology" (UNIDO/IS.270). The UNIDO Monitors on microelectronics and genetic engineering and biotechnology also provide information on this subject.

9/ For the report of the discussion meeting on information technology for development, see ID/WG.419/13.

10/ See, for example, "The potential impact of microbiology on developing countries" (UNIDO/IS.261); Priorities in Biotechnology Research for International Development. Washington, D.C., National Academy Press, 1982); Van Hemert, P.A., Lelieveld, H.L.M. and la Riviere, J.W.M. (Eds.) Biotechnology in Developing Countries. Delft University Press, Delft, 1982.

11/ See "Integration of emerging and traditional technologies in alcohol production", presented by L.C. Monaco to the Tokyo workshop on the integration of emerging and traditional technologies (April 1984). The UNIDO secretariat is also elaborating a concept of a biomass-based strategy for industrial development.

12/ See "State-of-the-art Series on Microelectronics, No. 3, Republic of Korea", (UNIDO/IS.490).

13/ See "Report on the identification and application of relevant new technologies for the implementation of the programme for the Industrial Development Decade for Africa" (UNIDO/OED.137).

14/ See "Monitoring progress made in accelerating industrialization in the developing countries". Third survey 1981-1983. (UNIDO/IS.499).

15/ See "Report of the International Forum on Technological Advances and Development" (ID/WG.389/6).

16/ ID/CONF.5/46, chap.II, sect.B (ID/CONF.5/RES.2, para.12(h)).

17/ For an earlier study by the secretariat, see "Application of biotechnology and genetic engineering to African fermented food processes" (UNIDO/IS.336).