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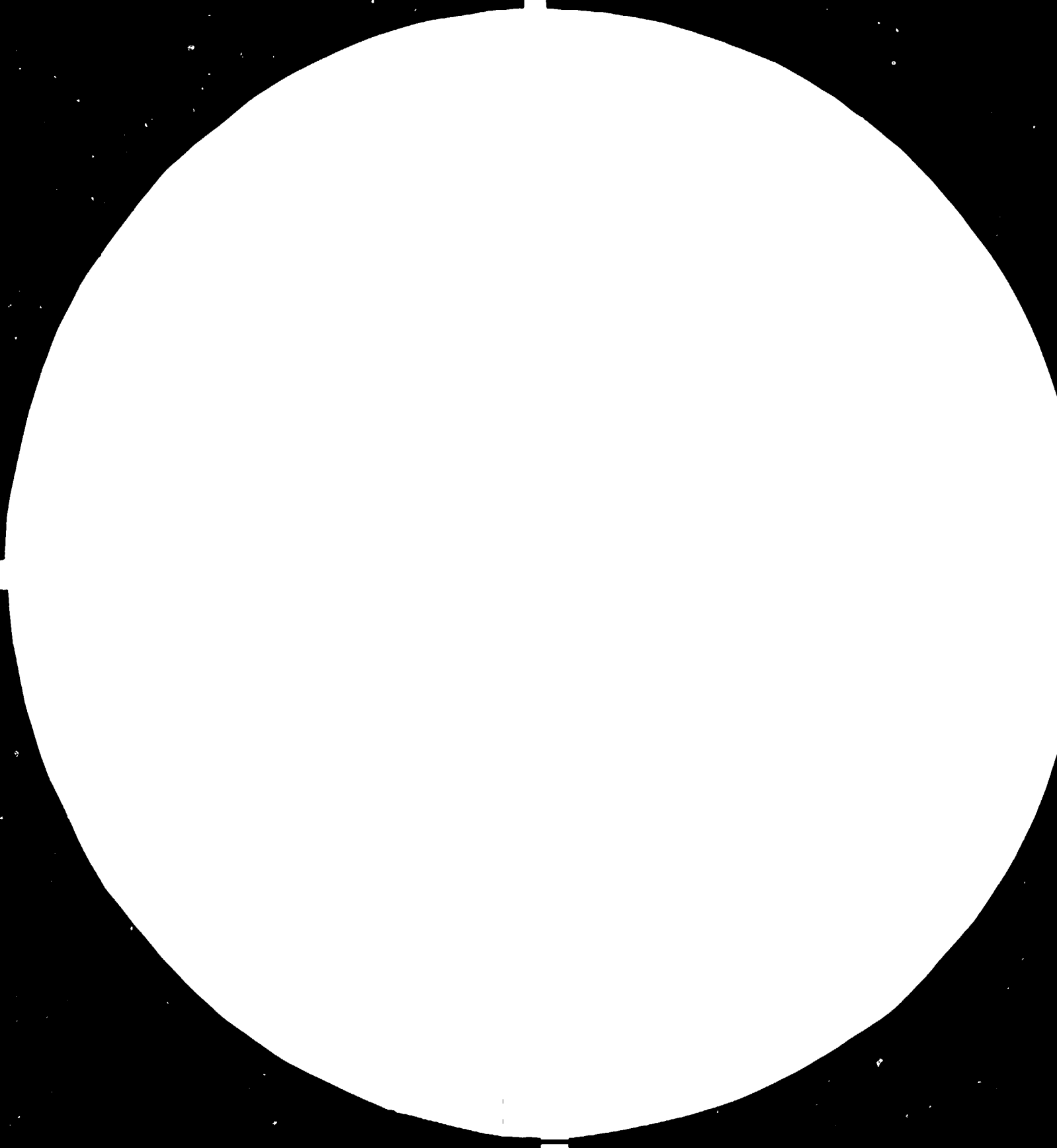

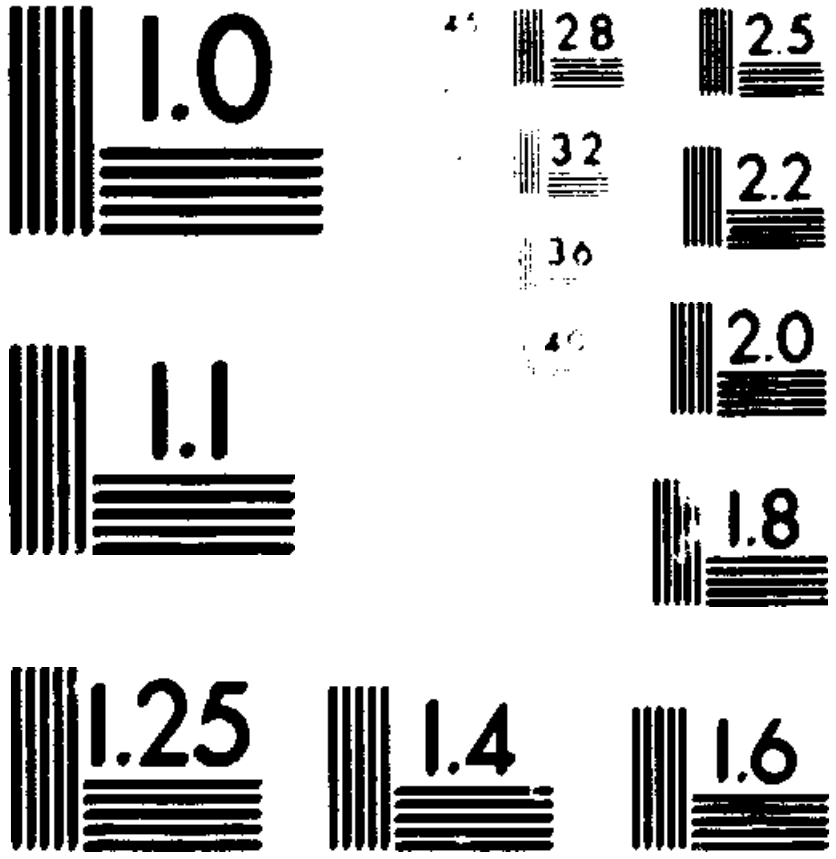

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Expert Group Meeting on the Implications of New Technologies in the Implementation of the Lagos Plan of Action and the Programme for the Industrial Development Decade for Africa

Mbabane, Swaziland, 22 - 26 October 1984

REPORT ON THE IDENTIFICATION AND APPLICATION OF RELEVANT NEW TECHNOLOGIES FOR THE IMPLEMENTATION OF THE PROGAMME FOR THE INDUSTRIAL DEVELOPMENT DECADE FOR AFRICA */

Prepared by
the UNIDO secretariat

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C O N T E N T S

I. INTRODUCTION

1. Following a series of regional symposia and other meetings held in Addis Ababa, Monrovia, Nairobi and Rabat in 1979 and 1980, the Heads of State and Government of African countries undertook a critical evaluation of the economic situation in their countries and adopted the Lagos Plan of Action for the economic development of the region, for the period 1980-2000, during their extraordinary summit devoted to economic matters held in Lagos, Nigeria, in April 1980. The Lagos Plan of Action deals with all sectors of African development aimed at promoting the development of indigenous African capabilities necessary for the achievement of the twin goals of collective self-reliant and self-sustained development.

2. In recognition of the pervasive and pivotal role which industry plays in economic development, the OAU Heads of State and Government accorded, in the adoption of the Lagos Plan of Action, the second highest priority to the industrial sector, the first being accorded to self-sufficiency in food production. In order to accelerate and facilitate the implementation of the industry chapter of the Lagos Plan of Action, they proclaimed the 1980s as the Industrial Development Decade for Africa, first, to generate greater awareness in the African countries of the need to take urgent action towards the accelerated industrialization of the continent and, second, to mobilize greater international technical and financial support for the African countries in their industrialization endeavours. This proclamation subsequently received international recognition when the United Nations General Assembly, on the recommendation of the Third General Conference of UNIDO, adopted resolution 35/66 (B) proclaiming the Decade.

3. Following the proclamation of the Decade, the OAU, ECA and UNIDO jointly formulated proposals for the programme for the Decade which was adopted by the Sixth Conference of African Ministers of Industry in 1981. These proposals, which have subsequently been endorsed by the OAU Heads of State and Government and by the United Nations General Assembly and printed in UNIDO document ID/287, provide a framework for the formulation and implementation of the programme for the Decade at the national, regional and international levels.

The OAU, ECA and UNIDO also identified priority actions for the implementation of that programme during its preparatory phase (1982-1984) which were also endorsed by the African Ministers of Industry. These are reproduced in UNIDO document ID/310.

4. The programme for the Industrial Development Decade for Africa is based upon the broad guidelines and orientation provided in the Lagos Plan of Action. Its ultimate objective is to contribute to the attainment of self-sufficiency in food production in Africa, the highest priority accorded in the Lagos Plan of Action. It is also directed towards the development and provision of the wide range of industrial inputs and services required for the development of the other sectors, especially agriculture, transport and communications and energy. It establishes a target of 1.4 per cent share in world industrial production to be attained by the African countries by the year 1990 and accords priority to the development of the food industry, building materials industry, metallurgical industry, engineering industry, forest industry, textile industry, as well as to the development of industrial manpower, technology, energy, raw materials, institutional infrastructure and financial resouces, all of which are important factor inputs in the industrialization process.

5. In accordance with the guidelines provided in the programme for the Decade, action has been initiated at the national and subregional levels. At the same time, UNIDO is developing a complementary programme in such areas as energy, industrial training and technology. It is within the framework of the complementary technology programme that UNIDO has considered it desirable to solicit the advice of experts on the identification and application of new technologies in the African countries. This is considered an important aspect of the technology programme to be formulated. As a start, it has been considered appropriate to limit consideration, in addition to policy aspects, to only two areas: genetic engineering/biotechnology and microelectronics.

6. As a follow-up, UNIDO took advantage of the joint OAU/ECA/UNIDO/UNCSTD expert group meeting on the implications of new technologies in the implementation of the Lagos Plan of Action and the programme for the Industrial Development Decade for Africa, which was held in Mbabane (Swaziland),

22-26 October 1984, to discuss with the experts invited by UNIDO (list attached in Annex I) possible measures and actions to be undertaken at the national, subregional/regional and international levels in the identification and application of relevant genetic engineering/biotechnology and micro-electronics technologies in the implementation of the programme for the Industrial Development Decade for Africa. The proposals and recommendations made by the experts are summarized in Chapters II and III below.

II. POLICY CONSIDERATIONS IN THE DEVELOPMENT, IDENTIFICATION AND APPLICATION OF NEW TECHNOLOGIES IN THE IMPLEMENTATION OF THE PROGRAMME FOR THE INDUSTRIAL DEVELOPMENT DECADE FOR AFRICA

7. Success in the local development and/or identification and application of existing new technologies in the African countries will be greatly influenced by the ability of Governments to perceive the need for, and the potential of, those new technologies, and to take necessary action (in terms of policy and infrastructure, as well as financial and human resources) to acquire the capabilities. In the industrialized countries, many of the developments in the field of new technologies have been dictated by market forces. The situation in the developing countries, particularly in the African countries, is such that the indigenous market forces alone cannot be counted upon to bring about developments in new technologies, given the high investment costs required and the poorly developed local market forces. In addition, the size and scope of the market are far too small to elicit appropriate demand for most of the industrial products. Governments therefore have to take the initiative to create demand for locally manufactured goods and divert local tastes from imports to local products. The creation of local demand should be the cornerstone of an industrial production programme which must also be matched with the price structure for industrial inputs and outputs.

8. Consequently, Governments will need to participate in international efforts directed towards the development and utilization of new technologies in order to ensure that their national, regional or subregional interests are safeguarded. In order to carry out such efforts effectively, each African country, region or subregion must clearly identify those needs and problems

for which some of the new technologies can be applied as suitable solutions. On the basis of such clearly identified requirements, various technological options ranging from traditional to new technologies will need to be examined with a view to identifying the most suitable manner of application, taking into account local resource endowments, particularly raw materials, trained skills and finance. All these need to be clearly articulated in a national, regional or subregional policy on the development and/or identification and application of new technologies in industrial and economic development. Such a policy would have to be integrated within the framework of a national, regional or subregional technology policy which, in turn, should be integrated with the relevant industrial and economic development policy. The elements to be considered in the formulation of the above-mentioned policy would have to place emphasis on capability and skills development, technology generation, and external assistance.

Human resources development

9. The key to all development is centred around human resources which are accorded high priority in the Lagos Plan of Action and in the programme for the Industrial Development Decade for Africa. The ability to exploit technological advances is closely related to the ability to develop the skilled personnel to utilize research results. The transdiciplinary character of technological advances means, in many cases, that the traditional system of education would have to be altered drastically in order to build trans-disciplinarity into it. Education and training should be aligned to the immediate needs of the country in terms of the projects required in various sectors. It is important that efforts be taken at the national, regional and subregional levels to adjust educational curricula so as to introduce the teaching of science and technology. The early introduction of practical skills and scientific education into the programmes and curricula for primary and secondary education would provide a good base for industrial and vocational education instead of the general education that now prevails in many African countries. Such training should, therefore, combine formal methods with the practical methods of learning-by-doing.

10. An important consideration in the development of human resources is the application of modern microelectronics technology to education and training. An analysis of human resource requirements in Africa reveals that Africa has to develop, within a very short space of time, a great number of policy and decision makers, managers, technologists, technicians, as well as skilled and unskilled labour, if the goals and targets established for the Industrial Development Decade for Africa and the Lagos Plan of Action are to be achieved. This means that new education and training methods and techniques have to be adopted and existing ones improved. One mechanism that has found wide and successful application in other countries relates to the use of modern microelectronics technology in human resources development through the use of computerized and video cassette training courses and satellite communication. This offers the advantage of reaching a wider mass audience, and provides audio-visual demonstration effects, particularly applicable in rural areas.

National core group of experts

11. The first and foremost task in any national effort in the development/application of new technological advances is to build up a minimum level of science and technology capability. One part of this capability could be with one or more core groups of experts the key areas. The main functions of these core groups would be to help in the identification and analysis of national, regional and/or subregional needs and requirements in each of the selected areas of new technology as well as to collect and assess information on current and future developments in those areas with a view to identifying those that are most relevant to local needs and requirements. They would also assist in the formulation of national, regional and/or subregional policies for the development, identification and effective application of the new technologies to the industrial and socio-economic development of the country, region and/or subregion as well as to the promotion of a greater understanding of such technologies within the country, especially in the public and private sectors. An important aspect of the responsibilities of such core groups would be to assess national, regional and/or subregional training needs and formulate proposals for training programmes and provide advisory services to industries, especially small- and medium-scale industries, and local entrepreneurs working in the relevant technological areas. They would also

liaise with regional/subregional and international organizations working in their respective technological areas. As such, these core groups would contribute to building up national, regional or subregional intelligence capacities in the selected areas of new technologies. The main functions of such core groups in the areas of genetic engineering/biotechnology and microelectronics are summarized in the recommendations given in Chapter III.

Technology generation and research

12. Technological advances create a certain need for basic research. Depending on available resources (both human and financial), expert groups would have to be set up at the national, regional or subregional levels within existing institutions or relevant departments of universities in selected areas such as biotechnology/genetic engineering and microelectronics, which would help not only to enhance technology awareness and assessment, but also initiate and conduct research - if only in a limited manner. The core groups on genetic engineering/biotechnology would take full advantage of the International Centre for Genetic Engineering and Biotechnology (ICGEB) and its affiliated centres as well as other relevant sources of technology. National, regional and subregional institutions would need to be strengthened and new ones established, as necessary, to generate problem-solving adaptive technologies. These institutions, especially the new ones, need to be decentralized and attuned to the needs of the people.

13. In the light of the above, Governments would need to adopt appropriate policies for strengthening indigenous research capabilities and capacities in basic as well as applied research which, above all, should be problem-oriented and geographically specific. In this regard, the need to develop an action-oriented extension service programme becomes particularly relevant. Unless the new technologies reach the end-users, little industrialization takes place. In the case of handicrafts or process industrial enterprises, entrepreneurs need to know better ways of using tools, maximizing returns from input-output ratios and putting their products on the markets. This also implies the development of an effective system concerned with the management aspects of projects, particularly small-scale projects.

Technical assistance from UNIDO

14. In all of the above, UNIDO should intensify its programmes of technical assistance to African countries and organizations in the formulation of technology policies and programmes in accordance with the resources of the countries, region and/or subregion, especially human, financial and natural resources, and with due consideration for local needs and priorities. This assistance should include the organization, in co-operation with the African Regional Centre for Technology (ARCT) or other appropriate national, regional or subregional centres, of training programmes including workshops and study tours for African experts and policy makers to familarize them with new developments in the selected technological areas and their possible application in African countries. An important area of technical assistance would be to provide advice to newly created enterprises in the application of new technologies; many projects fail for want of technical guidance, financial back-up and management counselling.

III. PROPOSALS FOR NATIONAL AND REGIONAL/SUBREGIONAL ACTION IN THE FIELDS OF GENETIC ENGINEERING/BIOTECHNOLOGY AND MICROELECTRONICS

Genetic engineering/biotechnology

15. Both the Lagos Plan of Action and the programme for the Industrial Development Decade for Africa accord highest priority to the attainment of self-sufficiency in food production in Africa in order to alleviate the constantly worsening food crisis on the continent. In addition, the African countries have serious problems related to human health, animal husbandry and agriculture. However, new biotechnology techniques discovered during the past 10 years, including gene-splicing, tissue culture and micro-propagation, will come to have a significant positive impact on these problem areas. Although most of the developments in the new biotechnologies have been undertaken outside Africa, important research is being carried out by institutes and universities in some African countries, for example, the Egyptian Serums and Vaccines Research Institute and the International Institute for Tropical Agriculture in Nigeria. The R&D performed in these and other African institutions could be considerably enhanced by applying results from foreign research, especially in the quest for solutions to African problems.

16. Important benefits likely to result from new scientific and technological breakthroughs in biotechnology, especially genetic engineering, will have an impact on several areas of concern to Africa. In the field of human health, new vaccines are being developed against malaria, schistosomiasias and other previously intractable diseases. Monoclonal antibodies and DNA probes will be used to detect and differentiate infections and other diseases at earlier stages than previously possible, as well as to identify early in pregnancy offspring suffering from inherited diseases, such as sickle-cell anaemia. In animal husbandry, new techniques will similarly be used to manufacture vaccines against economically damaging diseases, including African swine fever, foot-and-mouth disease and tuberculosis. Other techniques may be used to accelerate animal growth, enhance their size and to stimulate milk production. In agriculture, cell culture and genetic engineering will find use in the development of hardy plants, highly resistant to environmental stress such as heat, aridness, highly saline soils and high metal concentration. In the food industry, traditional fermentation techniques are being improved and extended, thus building on existing technologies to open new possibilities of introducing tastier and more nutritious foods for the population. The use of biological pesticides is likely to increase gradually and in the process take the place of chemically derived pesticides which are expensive and tend to degrade soils.

17. One of the most significant contributions of new technologies is the application of genetic engineering/biotechnology to the improvement of human health. In the field of genetic diseases, the typical anaemias of Africa (sickle-cell anaemia; thalassemias) can be approached at two levels: at present, genetic engineering techniques are used to develop simple assays for prenatal diagnosis and, for the future, hopes for direct gene therapy of the affected patients are conceivable. In view of its great and specific interest to African countries, field research at both the diagnostic and therapeutic levels is particularly relevant. In diagnosing infectious and parasitic diseases, the application of the new biotechnologies using monoclonal antibodies and genetic engineering are urgently needed: one such case is hepatitis B, so widespread in Africa and often leading to liver cancer. The new biotechnologies have extended in particular the possibility of producing of safe and efficient vaccines. In the first place, the production of traditional vaccines can be greatly improved by cloning specific gene(s) for

the antigene(s) responsible for eliciting immunity. This can abolish unwanted side-effects due to the presence of contaminants, and improved vaccines for diphtheria and cholera are currently under development. Furthermore, new vaccines are being developed for malaria, trypanosomiasis, onchocercosis, schistosomiasis and amoebiasis, the five parasitic diseases identified as most important in the region: in this regard, the progress already achieved in developing of a new vaccine for malaria is considered most encouraging. All the new developments mentioned above rely in fact on two basic production technologies, both requiring low cost industrial equipment. These are the mass culture of micro-organisms (usually the bacterium Escherichia coli or the yeast Saccharomyces cerevisiae, both appropriately engineered), or the massive production of animal tissue cultures for the production of monoclonal antibodies or other molecules (vaccines, interferons) not amenable to bacterial production. This makes them particularly interesting to African countries whose populations can certainly derive great benefits from these new diagnostic and therapeutic developments.

18. The above diagnostic and therepeutic developments arising from new genetic engineering/biotechnologies also find great application in animal husbandry. In addition, genetic manipulations of fertilized eggs could conceivably be applied to animal husbandry in order to produce cattle endowed with greater nutritional value (e.g. by the production of genes for the growth hormone or greater milk production) or more resistant to diseases. The application of these genetic manipulation techniques to cattle are also in progress. In this regard, the diffusion of artificial insemination techniques and embryo transplantation may increase cattle-breeding yields: the use of growth hormones in the raising of animals may also lead to greater meat and milk productivity.

19. Although the most significant benefits from the new techniques will affect human and veterinary medicine, important applications will also be made in the areas of energy, mining and agriculture. For example, in the field of energy new micro-organism strains will more efficiently convert the earth's most abundant resource, biomass, into primary energy substances such as biogas and alcohols. In mining, hardy strains will leach out large quantities of copper and uranium from mine tailings now discarded. In agriculture, genetic engineering will be used within 10 years to improve crop strains, and within

20 years it is likely that plants will be fixing their own nitrogen (converting atmospheric nitrogen into easily assimilated plant nutrients), thereby eliminating the need for artificial fertilizer.

20. In addition, a considerable amount of the genetic resources of indigenous crop plants in Africa are being rapidly developed through modern farming methods such as mono-cropping and the use of varieties with uniform genetic structures. Natural disasters such as droughts, floods and fires as well as land developments for roads and new establishments - all contribute to eradicate plants with useful genes. Genetic resources can be collected and preserved. They can also be generated through plant breeding methods. However these methods are extremely laborious, expensive and time-consuming. New techniques of developing crop plants have been shown to be faster, cheaper and more productive.

21. The immediate or short-term application of plant tissue culture is in the speedy selection and development of new crop varieties with desired agronomic and nutritional characteristics such as high yield and increased protein content, disease and pest resistance, and drought tolerance, as well as long- and short-duration crops. Tissue cultures provide stable and uniform, plant products because the scientist has complete control of the materials' genetic structure from the outset; they reduce storage space, greatly decrease the time and resource inputs and are more productive than conventional breeding methods. Cultures may also be used for long-term in vitro conservation of crop genetic resources and provide a convenient method by which plant materials can be transported from one region to the other. In the long run, however, tissue culture technology may lead to the production of crops with tremendous agricultural and economic potential. It may lead to the creation of new crop species which can make their own fertilizers through nitrogen fixation, their own pesticides and herbicides. The rapid production of plant compounds for pharmaceutical and cosmetic industries can also be envisaged as a future potential of the tissue and on the technology.

22. Developments in genetic engineering/biotechnology have also made a significant contribution to food processing. African countries may derive advantage from the diffusion and improvement of traditional technologies in food fermentation and the utilization of agricultural by-products. These, in

turn, may be made more profitable and safe by the introduction of new biotechnologies. This is particularly relevant in view of the fact that many African countries are undergoing severe food shortages due to drought and to the reduction of arable land through "desertification". This suggests that Africa should give serious consideration to the application of new technologies such as the production of single cell proteins (SCP) on cheap available carbon sources such as flare gas (convertible to methanol), sucrose or cassava starch. SCP contains 50 - 80 per cent protein and can serve as an excellent protein food ingredient for animals. As such it releases cereal grains and legumes at present fed to animals for use as human food, thus increasing the total protein and caloric food supply. SCP does not require much arable land and only a small area for the factory of an optimum size of about 100,000 metric tons/year, plus storage space for the substrate and product. Furthermore, it does not require any protein input but only inorganic nitrogen.

23. New developments in genetic engineering/biotechnology have also found important application in pest control through the development of biological pesticides. The use of conventional chemical pesticides in agriculture has brought along with it a number of negative side-effects, such as their persistence in the environment, harm done to useful life, the possibility of carcinogenesis, direct danger to utilizers, their financial costs and the deterioration of animals due to their excessive use. The use of biological pesticides is likely to alleviate all the problems mentioned without creating new ones, since they are highly specific, break down rapidly in the field to innocuous end-products and are non-pathogenic. There is, therefore, a need for African countries to examine these developments and take advantage of aspects that are locally applicable.

Microelectronics

24. The application of modern microelectronics technology in the socio-economic development of Africa is already in wide practice. This includes the use of modern electronics and telecommunications equipment such as audio-visual equipment, computers and telecommunication transmitters and receivers. In spite of this, there is still great potential for a much wider application of modern microelectronics technology in the African countries,

especially in such critical areas as health, agriculture, industry, energy, education, transport and communications. In the industrial sector, in particular, microelectronics technology finds the widest application in such areas as the manufacture of chips and other products which incorporate microprocessors and software development, servicing and maintenance. Furthermore, a large number of the products and processes used in Africa will contain more and more microelectronic components in the future, requiring of Africa the capability to use and maintain them in appropriate systems. In this connection, one of the major transformations that has occurred in microelectronics relates to the telecommunications industry in which there has been a push from analogue to digital technology. This makes use of all the advances in microelectronics applicable to switching and transmission equipment. Complementing digital technology is the light-wave and fibre technology. Other key technologies in communications, which have experienced great development and, thus deserve particular attention, relate to satellite transmission and packet switching. The above have resulted in a dramatic improvement in power and flexibility coupled with significant decreases in cost, and size of switching and transmission equipment not only for both voice and data communications. Recent advances in microelectronics have given microprocessors and microcomputers precisely those advantages that make them appropriate for use, customization, development and manufacture in developing countries.

25. It is important, therefore, that African countries at the national, regional and/or subregional levels should make efforts to enter this technology in time in order to cope with the inevitable involvement which is sure to result. This is a matter of great urgency. Given the explosive revolution already underway in terms of complexity and variety of available microelectronics componentry and systems, those who fail to enter the technology at the early stages will face a much more difficult challenge in the future and, consequently, a much greater likelihood of finding themselves locked into a condition of dependency. The implication for Africa is that steps should be taken expeditiously to prepare for this new technology and to ensure for African nations their proper role in microelectronics as an element in their policies and strategies for technological development. This should take cognizance of the negative effects of microelectronics and ways of avoiding them should be sought.

26. The requirements for entry into microelectronics applications include the ability to meet accompanying costs. These costs include: the costs of electronic componentry (hardware) and the subsequent assembly and testing costs; the software and/or the programming to provide the software needed; the cost of the development systems and the costs of maintenance and service. It is to be emphasized that compared to the typical investment requirements for new fields these are relatively modest. The most important requirement in the long-term, however, is that for skills development. Four main types of skills are required. The first is for identifying and specifying applications of microelectronics in Africa. The second type of skill, and the predominant one for development, is for software identification, adaptation and engineering systems and equipment development. The third type of skill is for promoting wide adoption of microelectronic systems among local users. The final type is for servicing and maintaining of microelectronic systems.

Recommended action programmes

27. Since the application of the new technologies in industrial and economic development will have a number of economic, social and cultural implications, it is necessary for each African country to formulate a clear national policy and programme in the area of genetic engineering/biotechnology and microelectronics. The following recommendations are therefore being advanced for consideration in the elaboration of action programmes at the national, regional, subregional and international levels.

Actions at the national level

28. It is recommended that each African country should set up core groups of experts, within existing competent institutions or departments of university, to provide nuclei for developing the country's intelligence capacity on the genetic engineering/biotechnology and microelectronics industries. The major functions of these groups would include the following:

(i) To identify the needs and problems in the country that may be amenable to solutions derived through genetic engineering/biotechnology or microelectronics.

(ii) To identify the natural resources in the country that may be profitably exploited on a sustainable level through genetic engineering/biotechnology or microelectronics.

(iii) To take inventories of, and catalogue, all the indigenous traditional and other existing methods and techniques which may provide a base from which advanced genetic engineering/bitechnology or microelectronics technologies could be developed.

(iv) To assess the scientific and technical resources of the country in order to clarify for its decision makers and scientists the areas in which R&D programmes could immediately commence, using advanced genetic engineering/biotechnology or microelectronics techniques. Such resources include scientific manpower, institutions and universities where notable R&D is being performed, special skills vested in scientists or researchers, special equipment, etc. Further, the assessment could be used to identify areas of immediate interest to the country and which could be readily strengthened.

(v) Similar to (iv), to assess the resources available at the subregional and regional levels of which the scientific establishment in the country could avail itself in order to solve its problems and utilize its resources more effectively.

(vi) To collect and analyze information from or about past and current developments taking place elsewhere in the world in the genetic engineering/biotechnology and microelectronics fields, and to identify those that are most relevant to alleviating the country's needs and problems (as identified in (i)) or exploiting its unique national resources (as in (ii)).

(vii) To formulate and present proposals to the Government for policy measures to be adopted within the framework of national economic and industrialization policies for the judicious choice and effective application of genetic engineering/biotechnology and microelectronics to industrial and socio-economic developments.

(viii) To promote a greater understanding of genetic engineering/biotechnology and microelectronics in industries, especially in the small- and medium-scale industries, and to encourage the judicious selection and application of those techniques.

(ix) To assess national training needs in the fields of genetic engineering/biotechnology and microelectronics and to formulate proposals for training programmes not only at the primary, secondary, university and post-

university levels but also for industry. In this connection, special attention must be paid to the interdisciplinary character of genetic engineering/biotechnology and microelectronics which therefore require scientific and technical manpower trained in biochemistry, genetics, microbiology and molecular biology, material sciences, electronics and telecommunications.

(x) To collect and analyze, in respect of microelectronics, information on the application of modern microelectronics technology in the accelerated development of human resources and the formulation of proposals for a national programme on the application of those aspects appropriate for the country. This is particularly important since microelectronics can fill a very important gap between rural and urban areas and between scientists and end-users. Areas in which government policy can be directed include the use of audio-visual aids in teaching, research and extension at all levels. The agricultural, educational, health and industrial (business) sectors should be given priority in accessibility to microelectronics.

(xi) To provide extension services to industries, especially small- and medium-scale industries, as well as to local industrial entrepreneurs working in the field of genetic engineering/biotechnology and microelectronics.

(xii) To liaise with subregional/regional and international organizations, especially with the International Centre for Genetic Engineering and Biotechnology (ICGEB) and its affiliated centres, as well as with similar centres working in the field of microelectronics.

(xiii) To set up, as necessary, one or more review committees in order to appraise and review research and R&D proposals, whether from academic or industrial units.

29. It should be recognized that setting up the core groups with the functions described above is only part of a country's commitment to developing its potential in genetic engineering/biotechnology and microelectronics. The Government would, in addition, have to take on a number of responsibilities, only a few of which can be mentioned here. The major responsibility is to provide incentives for scientists to work unhindered and an attractive renumeration for them to carry out R&D projects to their end. Other governmental responsibilities include: providing facilities to accelerate customs clearance for equipment and other materials imported for research and related projects; making available hard currency for the purchase of vital equipment, reagents, books and journals; readjusting or upgrading the educational system in order to allow for the proper education and training of

researchers; providing credit for the setting up of bioscience-based and microelectronics industries; and, if necessary, providing outlets for products produced through genetic engineering/biotechnology and microelectronics.

Actions at the Regional/Subregional Level

30. It is recommended that one or more suitable existing African institutions such as the African Regional Centre for Technology (Dakar, Senegal), the Egyptian Serums and Vaccines Institute and the International Institute for Tropical Agriculture (Ibadan, Nigeria), and similar centres working in the field of microelectronics should be identified and designated to act as focal points on the continent for promoting intra-African co-operation in the fields of genetic engineering/biotechnology and microelectronics. Activities to be undertaken by these focal point institutions would include the following:

(i) To identify, list and publish compendiums containing institutions (governmental or private, departments of industry or universities) and experts working in the fields of genetic engineering/biotechnology and microelectronics.

(ii) To promote the establishment of a network of genetic engineering/biotechnology and microelectronics institutions identified in (i) above, in order to exchange experience and information and harmonize the approaches and strategies adopted by African countries in the development and application of genetic engineering/biotechnology and microelectronics.

(iii) To promote and catalyze the undertaking of joint programmes of research among two or more of the institutions identified in (i) above in areas of interest to the subregion or region in which genetic engineering/biotechnology or microelectronics research could be effectively applied.

(iv) To strengthen the capabilities of an ever-increasing number of research institutions in Africa to perform advanced R&D in the fields of genetic engineering/ biotechnology and microelectronics through activities undertaken in (ii) and (iii) and through other actions that are deemed appropriate.

(v) To collect and analyze, in respect of microelectronics, information on the application of modern microelectronics technology in human resources development and the sensitization of African countries to this information, including the organization of regional or subregional meetings on the subject, and the formulation and promotion among potential investors of investment projects aimed at the establishment of microelectronics industry, especially those related to the production of training/learning kits and aids (e.g. video cassettes and computerized training courses).

Actions at the International Level

31. UNIDO and other relevant international organizations should intensify their programmes of assistance to African countries and organizations in the areas of genetic engineering/biotechnology and microelectronics. Priority should be accorded to the following types of assistance:

(i) Fielding missions, at the request of Governments or regional organizations, to assist decision makers in African countries in identifying the possibilities that genetic engineering/biotechnology and microelectronics have for the sustained industrial development of their countries. Stress should be placed on the need to make national commitments for R&D in the long term and not to have inflated expectations for the short or medium term.

(ii) Strengthening the national core groups of experts described above and, through them, undertaking the development of programmes for enhancing national technological capabilities in those fields.

(iii) Providing assistance to the African subregional/regional focal point institutions to allow them to promote better intra-African co-operation in R&D and set up bioscience-based and microelectronics industries, especially in the areas identified under actions at the regional/subregional level. Assistance may include the organization of regional/subregional meetings to discuss and make recommendations for the management of problems afflicting more than one African country.

(iv) Providing information to African countries, either direct or through the proposed African Technology Information Exchange System (to be established under the aegis of the African Regional Centre for

Technology), on past and current technological developments in genetic engineering/biotechnology and microelectronics. As possible, future directions in this area may be estimated in order to predict possible impacts of research on African countries.

(v) Promoting, within the framework of ECDC, co-operation between African countries and organizations and those in other developing regions of the world including co-operation in joint programmes and projects in the field of genetic engineering/biotechnology and microelectronics.

(vi) As there exists throughout Africa a shortage of equipment necessary to perform R&D in the areas of genetic engineering/biotechnology and microelectronics and to scale-up and industrialize results from research, the assistance to be provided should include the provision of basic necessary equipment and pilot plants. At the same time, facilities should be set up to standardize and fine-adjust new equipment, stock parts and to repair equipment as failures occur.

(vii) Providing special assistance in the mobilization of funds which could be utilized to scale-up and commercialize the results from either African or foreign research, in cases where needs are pressing and venture capital is unobtainable.

32. With regard to genetic engineering/biotechnology and in addition to the above-mentioned proposals, the International Centre for Genetic Engineering and Biotechnology (ICGEB) is requested to accord priority to the special needs of Africa for which special programmes should be developed, including the early establishment of at least two of its affiliated centres in Africa. In this connection, UNIDO should take the necessary follow-up action, including the provision of technical assistance to those African countries selected to host the above-mentioned affiliated centres.

IV. CONCLUSION

33. New technologies are here to stay. They offer new possibilities and opportunities for industrial and socio-economic development. Failure to recognize their potential and possible impact and take advantage of the new dimensions that they offer can only result in continued stagnation. It is therefore important for the African countries to bear in mind that their

industrial and technological policies for the 1980s and beyond would have to be developed and implemented taking into account the implications of the new technologies.

34. In presenting the proposals and recommendations contained in this report, full cognizance has been taken of the diversity among the African countries in terms of their natural, human and financial resources as well as their level of development. For this reason, the recommendations have been developed in a broad-based manner so that each country can determine its own starting point, depending upon its resource endowments and development options. However, the monitoring of technology trends and socio-economic assessment of their implications should be essential ingredients of policy and decision making in all the African countries. The formulation of appropriate policy responses to these emerging technologies has to be viewed as a strategic activity and given urgent attention.

35. It is recognized that the ability to exploit technological advances is closely related to the ability to develop skilled personnel to utilize research results. The development of such special skills would require a drastic readjustment of the current systems of education in most African countries in view of the transdisciplinary character of the new technologies. The recommendations for setting up one or more core groups in each of the selected new technology areas, as well as for strengthening indigenous capability and capacity in basic and applied research, as a decisive step towards building up a minimum level of science and technology capability, therefore warrant serious consideration by each African country. These actions will also require co-operation at the regional and subregional level. The recommendation to identify one or more suitable existing African institutions to act as focal points for promoting intra-African co-operation in the selected areas of new technologies is therefore pertinent.

36. The proposals and recommendations presented in the report and briefly highlighted above covering actions at the national, subregional and/or regional levels in the areas of genetic engineering/biotechnology and microelectronics would require a number of policy considerations. These are also presented in the report and relate to the development, identification and application of new technologies in the implementation of the programme for the

Industrial Development Decade for Africa. These actions will also require a significant injection of international assistance. The critical catalytic role of UNIDO in bringing about mobilizing such assistance for the effective implementation of these recommendations is recognized. UNIDO has therefore been requested to take necessary steps to initiate appropriate action accordingly.

ANNEX

List of experts contributing to the formulation of proposals on the application and identification of relevant new technologies for the implementation of the Industrial Development Decade for Africa

A. Outside experts invited by UNIDO:

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B. Experts from the UNIDO secretariat

19. Mr S.N. Ndam, Chief,
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20. Mr G. Tabah, Industrial Development Officer,
Development and Transfer of Technology Branch

21. Mr K. Fialkowski, Senior Industrial Development Officer,
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22. Mr R. Zilinskas, Industrial Development Officer,
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