



TOGETHER
for a sustainable future

OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.



TOGETHER
for a sustainable future

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

19984

Distr.
LIMITED

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

TECHNICAL REPORT
No. 19984

ORIGINAL: ENGLISH

CONTRIBUTION OF BIOTECHNOLOGY TO SUSTAINABLE
DEVELOPMENT WITHIN THE FRAMEWORK OF
THE UNITED NATIONS SYSTEMS*

Prepared by

M. S. Swaminathan**

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has not been edited.

** Centre for Research on Sustainable Agricultural and Rural Development, Madras, India.

Preface

This paper has been prepared in response to a decision taken at a meeting of the United Nations ACC Task Force on Science and Technology for Development, held in New York from 6 to 8 February 1991. At that meeting it was agreed that the Task Force should concentrate over the next year on the area of the contribution of biotechnology to sustainable development and that a paper would be prepared to cover the national, regional and international (NGOs and UN) system/levels, with particular reference to socio-economic and legal implications, ethics, safety, the impact on employment, the international division of labour, etc. The paper was to be both analytical and forward-looking, with specific recommendations.

The Task Force agreed that UNIDO should take the lead in preparing the paper, with inputs from concerned organizations and agencies. The audience for this publication was to be the policy-making organs within the UN System that address biotechnology-related issues.

Though this paper is still subject to discussions by the ACC Task Force, it was agreed with the Chairman of the Task Force to already bring this paper to the attention of a larger audience in the context of the 4th Session of the UNCED Preparatory Committee, 2 March - 3 April 1992.

Revision 1, incorporates additional inputs received from some of the agencies.

2.5 United Nations Environment Programme (UNEP)

UNEP, the organization created by the International Community to implement the Plan of Action on the Human Environment has initiated several activities in biotechnology promotion which are summarized below.

UNEP and the growth of biotechnology: Since inception, UNEP has realized the importance of and has promoted activities aimed at conserving the world's genetic material: plant, animal and microbial, and promoting their application for sustainable development. At an Expert Group meeting on microbiology at UNEP Headquarters in Nairobi in early 1974, the concept of microbiological Resources Centres (MIRCENS) was formulated with aims, among others, to foster development and continued application of environmentally sound biotechnologies. The Governing Council of UNEP decided at its fifth session (1977) that the establishment of a network of MIRCENS should be one of the organization's goals to be achieved by 1982.

As a result, eight regional MIRCENS, each consisting of a regional network of collaborating laboratories (institutions), with one laboratory serving as a coordinating centre for the region, were established in Bangkok, Beijing, Cairo, Dakar, Guatemala City, Porto Alegre and Pune. A World Data Centre of Microorganisms (WDC) which is now at the Institute of Physical and Chemical Research in Hiroshima was also created as a global register for computerized storage, retrieval and distribution of information on microbial genetic resources. The WDC provides the following services at no cost to users: identification of unknown microorganisms; supply of data on any particular taxon; acceptance of data from research workers; provision of information on the geographical distribution of organisms' host ranges and the occurrence of organisms with specific properties; provision of lists of contents of collections registered with the Centre; and supply of data on a centre's own culture collections on punch cards for use in local operations. The Centre also assists regional MIRCENS to continue the development of regional culture collections, the production of regional catalogues of microorganisms of environmental and economic significance and to continue the training of scientific and technical manpower required for the development of culture collections in developing countries.

A further step in the distribution of information on microbial gene pool and cell lines, that can be tapped for economic development and environmental management, was the establishment - with UNEP support of an International Microbial Strain Data Network (MSDN), now housed by the Biotechnology Centre at Cambridge University, as a global referral system for information on microbial strains and cell lines.

Biotechnology and bioproductivity

To promote the widespread application of these technologies for environmental management in developing countries, UNEP is supporting a number of preparatory phase pilot projects in close association with regional MIRCENS, each concentrating on specific environmental problems of high national relevance. Among these are:

1. Biological nitrogen fixation (BNF) for increasing soil fertility

Interest in BNF prompted UNEP, in collaboration with FAO, to survey the state of its application, expertise and potential in developing countries in

Africa, Latin America and Asia. The results of the survey were sufficiently encouraging for UNEP to embark on a number of projects to assist several developing countries in initiating field work to popularize the technology for enhancing soil fertility and increasing legume production at the small farm level.

A number of activities are presently being conducted with the joint support of UNEP, FAO, UNDP, the Arab Gulf Programme for UN Development Organizations (AGFUND) and various governments. Four of the MIRCENs, namely Cairo, Dakar, Nairobi and Porto Alegre are cooperating closely in these efforts. These activities include collection, evaluation, preservation and periodic testing of Rhizobium strains and the establishment of pilot plants for Rhizobium inoculant production; trials on legume inoculation; testing of peat resources for their suitability as inoculant carriers; studies on nitrogen fixation by casuarina with Frankia studies on inoculation of Sesbania rostrata; and training of local biological nitrogen fixation professionals, technicians and extension workers.

2. Microbial agents for biological control of pests and vectors

With the support of UNEP, one MIRCEN coordinated programme is also in progress at the Bangkok, Cairo and Nairobi MIRCEN laboratories for translating research results in the area of biological pest and vector control into applications as an appropriate approach offering an environmentally sound long-term alternative to the continued use of chemical pesticides. Active strains of locally-isolated Bacillus thuringiensis were collected and tested under laboratory conditions. The insect rearing capabilities of the MIRCEN laboratories were strengthened, specialized regional training courses were organized and testing of active strains against mosquitoes and houseflies has been initiated.

3. Microbial degradation of environmental pollutants

A coordinated programme is in progress with UNEP support at the Biotechnology Laboratory of the Cairo MIRCEN for designing and testing microbial technologies under field conditions for the biodegradation of key persistent insecticides that are widely used in agriculture in the region and for developing local expertise in the application of the developed techniques.

4. Bioconversion of agro-industrial wastes

To promote the use of appropriate environmentally-sound biotechnologies for bioconversion of agricultural residues and surpluses into useful products in developing countries, UNEP is providing catalytic, technical as well as financial, support to both Bangkok and Guatemala MIRCENs. These efforts are focussing on the use of biotechnologies to strengthen rural economies through waste recycling for the production of food, feed, energy and/or organic fertilizers.

The future

The emergence of a new biotechnological revolution and the recent developments in genetic engineering offer a potential for linking conservation and optimum utilization of microbial genetic resources as well plants and animals. The relative ease of genetic manipulation of micro-organisms will make it possible to utilize such techniques for optimization of

characteristics and even for conservation of specific genetic determinants of certain plants and animals in microorganisms through genetic engineering or "recombinant DNA" techniques. The growing number of industrial processes to which biotechnology can be applied to satisfy human needs and aspirations makes it an area of global interest. Biotechnology is expected to offer significant benefits to society by increasing the production of food, energy and raw materials and alleviating or mitigating the problems of health and pollution. The world's dependence on expensive fertilizers could be reduced dramatically if food crops could be given the genetic ability to fix atmospheric nitrogen directly. Food production could be increased dramatically if food crops could be given the genetic ability to resist drought, pests and pathogens, salinity and other environmental stresses.

Biosafety

UNEP, as a member of the UNIDO/UNEP/WHO/FAO Informal Working Group on Biosafety is promoting safe applications of biotechnology in developing countries. UNEP, in collaboration with UNIDO, supports practical training in advanced biotechnologies and relevant techniques as well as in biosafety for personnel from the MIRCENS at the International Centre for Genetic Engineering and Biotechnology (ICGEB) location in Trieste. The training is aimed at linking the MIRCENS with the ICGEB and strengthening the MIRCEN capabilities in this area.

In this regard, UNEP, in collaboration with UNIDO and the international Microbial Strain Data Network (MSDN), initiated a global information system - the establishment of an International Information Resource for the Release of Organisms (both genetically modified and novel) into the environment. In March 1991, UNEP with financial support from U.S.EPA, CEC and Environment Canada organized a workshop on the needs and specifications of such a data base. An international steering committee was set up, contributing data resources were identified, a decentralized network was recommended for IRRO. The MSDN experience and infrastructure will be used to develop IRRO. Discussions are being conducted with OECD to put its data base (BIOTRACK) on IRRO. An inventory of existing data resources is being prepared.

Organization members of the UNIDO/UNEP/WHO/FAO Working Group on Biotechnological Safety are collaborating on the preparation of inter-agency guidelines for good environmental practices of biotechnology and developed a Code of Conduct on the Release of Genetically Modified Organisms into the environment.

* Extensively extracted from an article written for biopractice 1/1992, published by Spektrum Akademischer Verlag, Heidelberg, Germany.

2.11 United Nations Scientific, Educational and Cultural Organization (UNESCO)

The UNESCO programme in environmental and applied microbiology and biotechnological research traces its origins back to 1946. A decade later, UNESCO with the objective of advancing cell biology, particularly in developing countries, invited ICRO to promote research on microorganisms and a Panel on Microbiology was charged: to establish an international network for the preservation and exchange of cultures; to promote the use of microorganisms as a natural resource; and to assist in the training of microbiologists. Since that time, UNESCO activity in this field has been done in cooperation with ICRO and with the International Organization for Biotechnology and Bioengineering (IOBB) and the World Federation for Culture Collections (WFCC), both of which organizations were founded in the early 1970s with UNESCO support and encouragement.

UNESCO, in 1970, took the lead in the establishment of a network of Microbial Resource Centres (MIRCENS) directed to the needs of developing countries. MIRCENS serve the microbial community in the collection, preservation, identification and distribution of information relevant to the cultures and their uses, and in the development of research and training activities that are directed towards regional needs.

Consequently, at UNEP Headquarters in Nairobi early 1974, the concept of the Microbiological Resources Centres (MIRCENS) was formulated in consultation with UNESCO, ICRO and representatives of other bodies, and in 1975 an action plan aimed at the establishment of a pilot network of six MIRCENS in some developing countries of Asia, Africa, and Latin America to conserve microbiological resources and apply them in environmental management within the framework of a joint UNESCO/UNEP/ICRO project (1975/1984). Since 1984, the pilot network has been expanded by UNESCO into a worldwide mechanism of sub-regional, regional and international co-operation which aims at stimulating the participation of all Member States and preventing the "biotechnological revolution" from further aggravating disparities among countries in the field of science and technology. The MIRCEN mechanism is a cost-effective global network of twenty-three centres in nineteen countries on all five continents that has the following goals:

- International co-operation in the key areas of applied microbiology and the new biotechnologies;
- the promotion of regional co-operation in achieving the goals of self-reliance and sustainable development;
- the reinforcement of the nuclear institutions in the network as centres of research and training;
- the maintenance of the catalytic and spin-off benefits of the network.

Current efforts are focussed primarily on:

- the development of national political will and fiscal commitment towards the establishment of quality research;
- the development of infrastructure and human resources; and

the dissemination of knowledge in high-technology and low-technology skills as a means of channelling the "biorevolution" towards the improvement of the quality of life in less developed countries.

Microbial technology being multidisciplinary, is disseminated through inter-agency cooperation; for example UNESCO and a Panel on Microbiology organized several International Conferences on the "Global Impacts of Applied Microbiology" (GIAMs) with the co-sponsorship by several UN agencies (FAO, UNEP, UNDP, UNU, WHO) and non-governmental organizations (IUMS, IUBS, WFCC, etc.). These conferences were aimed at appraising and presenting to high government officials, administrators, research workers and students, the latest developments that have scientific, economic, environmental and social applications. These meetings have led to a cognisance of microbial technology as a means of furthering technological and sustainable development by governmental and policy decision-makers; counteracting the drainage of the microbial gene pool in Africa; introducing adaptive agriculture in Asia, Latin America and Africa; to the updating of microbiological curricula with a high awareness of the environment; and to the organization of national courses and fellowships in environmental biotechnology involving close collaboration between scientists from the developed and developing countries in diverse fields such as bioremediation and bioconversion technology of agro-industrial residues.

In 1990, UNESCO instituted Biotechnology Action Council (BAC) to develop a research and training programme short-term fellowships in the plant and aquatic biotechnologies.

Further, in 1993, 5 Professorships in the biotechnologies will be awarded. Simultaneously, 2 UNESCO Chairs in Plant Genetics and Biotechnology are in the process of establishment in China and Cuba respectively.

UNESCO, at the crossroads of education, science and culture and communication, offers a unique institutional setting for dealing with problems and management of the environment and natural resources that transcends sectoral interests, and for which, only integrated interdisciplinary approaches are appropriate for coping with their inherent complexity.

In the field of science and technology education, UNESCO addresses the improvement of biotechnological education in schools up to year 10 and aims at improving the quantity and quality of biotechnology taught in schools worldwide. On environmental education, UNESCO and UNEP jointly launched the International Environmental Educational Programme (IEEP) in 1975 to provide a framework of principles, objectives and strategies as contained in the Tullisi Declaration.

UNESCO's main areas of competence for the issues of sustainable development and biotechnology which are of relevance to the environmental sciences (inclusive of the natural and human sciences) are needed to understand those biotechnological components of the land, freshwater, coastal and ocean environments, to assess the state of the natural gene pool base, and to detect the causes and effects of environmental stress. Scientifically-sound information is a sine qua non for making sound "environment and development" choices. Many developing countries still have insufficient national capacity in the environmental sciences to ensure a sound scientific basis for policy and action.

In order to address the associator with sustainable development tasks at the international level and to assist developing countries, intergovernmental mechanisms have been set up within UNESCO in three areas that also benefit from UNESCO's close association with ICSU and its affiliated Bio-Unions and Scientific Committees. These are:

- Intergovernmental Oceanographic Commission (IOC): a body with functional autonomy within UNESCO aimed at promoting marine scientific investigations (e.g. fisheries, food chains, etc.) and related ocean services;
- Man and the Biosphere (MAB) Programme: aimed at developing within the natural and social sciences a basis for the rational use and conservation of the resources (animals, forests, plants, biodiversity) and ecosystems of the terrestrial biosphere;
- International Hydrological Programme (IHP) aimed at providing the scientific basis for the assessment and rational management of water resources, e.g. bioremediation of polluted waters.

UNESCO, furthermore, in keeping with its mandate has instituted a number of future-oriented studies e.g. "Biotechnologies in Perspective" to focus on the benefits and drawbacks on genetic engineering with its impact on the economy and development of a number of developing countries.

In addition, in attempting to disseminate an awareness of the environment and sustainable development with a view to upgrading the quality of environmental education and training, UNESCO has initiated a number of information mechanisms stressing that information by itself is not enough, and that getting involved is important.

Some examples of these, in brief are:

1. The international Newsletter CONNECT in environment education and conservation.
2. Nature & Resources, a quarterly review of research on sustainable development designed for conservation and optimal use of natural resources.
3. The UNESCO Environmental Brief Series, to provide an authoritative, objective overviews on topics of global importance.
4. World Journal of Microbiology and Biotechnology, to provide a forum for dissemination of research work.

UNESCO, in conjunction with several UNDP financed projects has promoted the establishment of biotechnology networks covering important fields of research such as plant tissue culture, vaccine production, genomic studies of plant viruses, establishment of biotechnological information exchange system (BITES) and the production of biofertilizers. Those networks have been established in Africa, Europe, Latin America and the Caribbean.

2.12 United Nations Industrial Development Organization (UNIDO)

Recognizing the potential of biotechnology for development and that the first order of its impact would be on industry, UNIDO initiated work 10 years ago on methods of identifying the effective transfer of benefits of biotechnology research to developing countries. This ultimately resulted in the establishment of the International Centre for Genetic Engineering and Biotechnology (ICGEB). The ICGEB has now 46 Member States and affiliated centres in 17 of these States. The research and development programme of ICGEB is dedicated to the application of genetic engineering and biotechnology to problems of relevance to developing nations of the world. The 1991 Activity Report of ICGEB gives an excellent summary of the work being done under its two components located at Trieste and New Delhi. The major thrust of ICGEB and its component units are as follows:

Agribiology - with an emphasis on crop improvement
Human health - with an emphasis on vaccine production
Biomass conversion - lignocellulose degradation.

The ICGEB component laboratories are crucial to the success of the mission of the Centre in providing a world-class scientific milieu in which scientists can learn and apply new techniques and transfer them to their native countries. Through a process of consultation involving the Preparatory Committee, the Panel of Scientific Advisors (PSA) and scientists from the Member States, the above research topics were selected as being most in keeping with the declared aims of ICGEB.

(i) Research at the Trieste component

Under the development plan for the Trieste component, the full complement of research and support staff will by 1993 be divided into five research groups, each led by a senior scientist and composed of three to six junior scientists, plus a number of trainee fellows and technicians. These groups will address research topics in:

Virology, molecular and cell biology;
Immunology;
Pharmacology;
Protein structure and engineering;
Microbiology.

The group members will be drawn from a wide range of disciplines relevant to genetic engineering and biotechnology giving the Centre a multi-disciplinary character. The groups will interact and collaborate on the various facets of the research areas described above.

At Trieste, interaction with the local scientific community has already been established. Access to a very powerful source of X-rays from a synchrotron, to be operational by 1992, will enable ICGEB scientists at Trieste to pursue state-of-the-art research in protein structure and engineering.

(ii) Research at the New Delhi component

The research staff at the New Delhi component of ICGEB when at full

strength (1993) will be divided into groups similar in structure to those at the Trieste component, each headed by a senior scientist and comprising a number of junior scientists, trainee fellows and support staff. These groups will be active in:

Plant biology;
Human diseases;
Structural biology.

The ICGEB has today become an extremely important institution with a global outreach through link centres. Its PSA comprises world leaders in biotechnology. The Centre will become autonomous with effect from 1 January 1993 with a Board of Governors comprising member states ratifying the statutes of the centre.

A number of technical cooperation projects in biotechnology have been implemented or are under implementation by UNIDO. An important example is the Regional Network for Biotechnology in Latin America and the Caribbean. UNIDO, with the financial assistance from the United Nations Fund for Science and Technology and UNDP, initiated in 1981 a preparatory phase of biotechnology activities in Latin America resulting in a regional programme and network.

Phase I of this programme funded by UNDP, was implemented jointly by UNIDO and UNESCO, with UNESCO covering the basic development of biotechnologies and products and UNIDO carrying out the technology development and industrial application of biotechnology. The programme's aim was to establish a framework for joint development policies in biotechnology, geared to solving regional priority problems through new products, processes and services. The programme's 13 country members formed a Regional Council as its top decision-making body. The Council selected nine biotechnology products of high regional priority, fostered training through training courses, workshops and fellowship programmes and identified 14 pipeline priority products and five priority areas not covered by the Programme. Follow-up activities are approved by UNDP.

To complement the activities, the network has also been affiliated to the ICGEB. UNIDO also implemented technical assistance programmes in the region at national and regional levels.

Other activities undertaken through UNIDO's operational activities in applied biotechnology related to:

- biogas technology (industrial scale);
- ethanol production by fermentation from sugar, etc.;
- chemicals made by biotechnology processes such as amino acids, citric acid, enzymes, etc.;
- composting;
- assistance provided in biochemical engineering development;
- membrane technology;
- microbial pesticides;
- microbial leaching;
- plant tissue culture;
- waste water treatment, etc.

UNIDO's promotional programme in the field of biotechnology contains the following elements:

| Programme element | Examples |
|---|---|
| (a) Identification of national and regional R&D priorities, monitoring of technological trends, sensitization of policy makers, scientists and technologists and the development of databases and bio-informatics networks. | Studies and policies and programmes in selected developing countries and on global trends in biotechnology etc. Development of a bio-informatics activity including a workshop in the USSR. |
| (b) National biotechnology policy formulation. | Biotechnology programmes in several African countries and advisory services under STAS. |
| (c) Research cooperation between institutions of industrialised and developing countries. | Programmes for research cooperation for vaccines, bioremediation of oil and enhanced oil recovery, lactic acid fermentation. |
| (d) Transfer of technology through investment promotion and technological cooperation at the enterprise level. | Expert group meeting on commercialization of biotechnology. Expert group meeting on the application of biotechnology to food processing in Africa. |
| (e) Monitoring regulatory issues, such as patenting and bio-safety; formulation of safety guidelines for biotechnology research and manufacture for developing countries. | Development of a voluntary international code of conduct on the release of genetically modified organisms into the environment. Provision of Biosafety Information and Advisory Service (BINAS) to developing countries |
| (f) National institution capability building through strengthening of R&D and production infrastructure and/or the International Centre for Genetic Engineering and Biotechnology (ICGEB). | ICGEB; institutional capability building in developing countries; increasing cooperation with affiliated centres. |

Thus, UNIDO is striving to serve the growth and spread of biotechnological capability in developing countries and in harnessing the tools of biotechnology for promoting sustainable development. Also, as mentioned earlier, UNIDO has initiated a bioremediation project to combat oil pollution and an oil recovery programme (BIOROR) to assist countries in enhanced oil production.

In addition to the above activities, UNIDO publishes the Genetic Engineering and Biotechnology Monitor since 1982, which has become a highly popular quarterly bulletin on developments in the field of biotechnology and genetic engineering including scientific as well as commercial developments. The Monitor helps the professionals, both in developed and developing countries in increasing current awareness without having to go through scores of journals.

2.15 World Intellectual Property Organization (WIPO)

Protection of Biotechnological Inventions

1. In the framework of the study of the problems relating to the protection of inventions in the area of biotechnology, in particular in respect of patent protection, the World Intellectual Property Organization (WIPO) convened the following Committees of Experts:

Committee of Experts on Biotechnological Inventions and Industrial Property

2. From 1984 to 1988, four meetings of the Committee of Experts on Biotechnological Inventions and Industrial Property were convened to consider whether the existing systems of legal protection for inventions were satisfactory so far as biotechnological inventions are concerned and, if not, to make suggestions for improving them. In the context of that Committee of Experts, the International Bureau of WIPO prepared a report on the industrial property protection of biotechnological inventions and suggested solutions concerning industrial property protection of biotechnological inventions, both of which were reviewed and commented on by the Committee of Experts.

3. The report referred to (document BioT/CE/IV/2), in its newly revised version, analyzes the existing situation with respect to the legal protection of biotechnological inventions by patents and plant breeder's rights and contains proposals for improving the legal protection of biotechnological inventions. The suggested solutions (document BioT/CE/IV/3) deal with those problems concerning the protection of biotechnological inventions in respect of which it appears advisable to offer solutions in order to improve the protection of this category of inventions and to promote international harmonization. Both the report and the suggested solutions address three main topics in relation to the protection of biotechnological inventions: (i) availability of protection; (ii) scope of protection; (iii) deposit of microorganisms.

Committee of Experts on the Interface Between Patent Protection and Plant Breeder's Rights

4. From January 29 to February 2, 1990, a Committee of Experts on the Interface Between Patent Protection and Plant Breeder's Rights was convened under the joint auspices of WIPO and the International Union for the Protection of New Varieties of Plants (UPOV). This Committee met to consider questions concerning the relationship between plant breeder's rights and patent protection, the extent to which these rights meet, conflict, overlap or present gaps in protection (document WIPO/UPOV/CE/I/2).

5. The questions considered and discussed by the Committee of Experts fell into five general categories: (i) whether patents and plant breeder's rights should both be available in respect of plant varieties; (ii) limitations on rights granted to take into account considerations with respect to the general nature of biological material and of the agricultural and horticultural industries; (iii) how the term "plant variety" should be defined; (iv) the question of dependent varieties (whether on another plant variety right or on a patent) and essentially derived varieties; (v) whether patent protection for processes for the production of plant varieties should extend to a plant variety directly obtained by such a process. Document WIPO/UPOV/CE/I/4 contains the report of that meeting.