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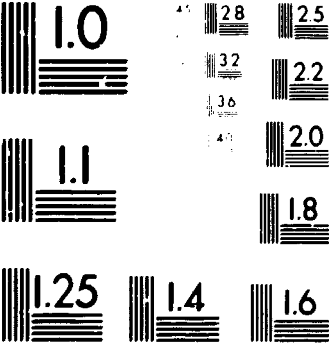
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THE POTENTIAL OF BIOTECHNOLOGY FOR THE GULF REGION AND THE ROLE OF THE ICGEB INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY*

prepared by

the UNIDO secretariat

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CONTENTS

INTRODUCTION

Biotechnology in the traditional sense has been employed by man since the ancient times of our civilization. Bread making, cheese and other fermented food stuff have been the products of biological or biochemical processes. Nevertheless, during the past decade new advanced techniques have been developed that enhance enormously the potential of traditional biotechnology. Most notable among those techniques is genetic engineering or, more scientifically speaking, recombinant DNA technology.

Its likely impacts on the world's economic development in areas such as health, food and industry will present nations with one of today's greatest challenges. The scientific and technological breakthroughs of those advanced techniques will prove to offer a wide range of opportunities combined with new dimensions of versatility, efficiency and economy.

In meeting this challenge, one need to consider the following important factors:

- The importance of developing a "critical mass" of skilled scientists and technologists and providing them with the necessary means and material to utilize these advanced technologies for solving the unique problems of their countries.

- The importance of identifying and focussing research efforts on those unique problem areas for which advanced biotechnology and genetic engineering could be efficiently applied.

- As a result of the two foregoing factors, the necessity of co-ordinating and integrating a variety of industrial technical and scientific skills in order to achieve a carefully selected set of objectives.

The goal to achieve the development of a functioning critical mass necessitates the creation of scientific teams with a mixture of different competences and skills in areas such as molecular biology, biochemistry, microbiology, etc. The structure of such teams will vary depending on what applications this technology will be needed for. Table 1 provides an example of the disciplinary components the critical mass requires for genetic engineering of microorganisms having applications in the fermentation industry.

Table 1

CHEMISTRY	
	Oligonucleotide synthesis
	General analytical chemistry
BIOCHEMISTRY	
	Nucleic acid enzymology
	Nucleic acid biochemistry
	Protein isolation and characterization
MICROBIOLOGY	
	Microbial genetics (bacteria, phage, plasmids)
	Microbial physiology
FERMENTATION TECHNOLOGY	
	Applied microbial physiology
	Product recovery
	Integrated process development

(Source: David Jackson: "Biotechnology: Tradition Technology and Targets", in Biotechnology in the Americas: Prospects for Developing Countries)

I. International Centre for Genetic Engineering Engineering and Biotechnology (ICGEB)

The additional dimensions which the technological advances in genetic engineering has on traditional biotechnology became apparent in the late 1970s. UNIDO realized the significant industrial dimension the technology will have in terms of new products and processes in a number of economic sectors such as food processing, chemical and pharmaceutical industries (including fertilizer), pesticides, detergents, feedstocks, recycling and waste treatment and last, but not least, in the energy sector.

In view of this realization, UNIDO in 1981, with the help of a number of distinguished scientists, took the initiative for the establishment of the International Centre for Genetic Engineering and Biotechnology (ICGEB). In launching this initiative, a number of considerations were foremost in the mind of the people behind it: First, that a well-endowed ICGEB could play a significant role in advancing the world-wide frontiers in this field. Second, it will ensure the accumulation and continuity of scientific knowledge which will be accessible to all participating countries. Third, that the Centre's unique feature of transdisciplinarity will be a major factor in assisting developing countries to achieve the critical mass of technological and scientific capabilities in this frontier technology. Fourth, the forceful argument forwarded by many developing countries regarding the role the ICGEB can assume to obviate a situation where "secrecy and monopoly" could result in a burden of excessive costs and limitations of access to the international flow of technology.

The Centre's activities will range from undertaking R+D (in areas such as the bioconversion of biomass, microbiology of hydrocarbons, large-scale fermentation and process development, protein engineering, the development of stress tolerance in plants, improvement of plants for nutritional contents, animal and human vaccine development) to setting up multidisciplinary teams (consisting of many scientists from developing countries who can carry out substantial research and development activities, including pilot plant operations). It is also envisaged that the Centre will provide other services to member countries including making available advisory services, the organizing of expert group meetings and workshops on problem-oriented topics, the dissemination of specialized information, etc.

During the Ministerial Level Plenipotentiary Meeting on the Establishment of the ICGEB, held in Madrid, 7-13 September 1983, 28 countries signed the Statutes of the ICGEB; they were later joined by 7 additional countries which makes a total of 35 countries up to date. Generous offers to host the Centre were presented by a number of countries. However, the signatories of the Statutes decided on 4 April 1984 that the Centre would consist of two equal components, one located in New Delhi, India and the other in Trieste, Italy.

At present, the Preparatory Committee (in which all signatory States are represented) is working towards the target of starting operational activities, including research and training in provisional facilities, at both components by March 1985.

II. Potential of Biotechnology for the Countries in the Gulf Region

(1) Hydrocarbon Microbiology

It is not new to state that the Gulf region is among the wealthiest regions of our world in the energy resource materials of petroleum and natural gas. Governments of the Gulf region have always sought technology independency in order to undertake there own oil exploration and processing and have been quite successfully in doing so. This can be witnessed by Gulf country governments' drive for setting up large petrochemical industries which will result in making some of the countries of this region to be among the main exporters of petrochemical products. The construction of the new petrochemical complexes at Yanbu and Jabail in Saudi Arabia stand as edifying examples of such efforts.

Much R+D is being performed in laboratories on microorganisms that can use components of petroleum as substrates. The use of these organisms in specific applications is becoming an economically important area of biotechnology. Included are applications pertinent to the refining of crude oil such as dewaxing, removal of sulfur and metals and partial refining. R+D work on enhanced oil recovery, which must take into account the specific characteristics of each source and of the type of petroleum to be recovered has seen steady development. Following are three general experimental approaches to enhance oil recovery:

(a) the stimulation of growth of indigenous microorganisms by the injection of nutrients into the well;

(b) the injection of laboratory-selected microorganisms into the well;

(c) the production by microorganims of specific biological compounds and the subsequent use of these compounds in wells as surfactants and detergents.

Another equally important area of application for biotechnology and genetic engineering is pollution control in oil processing industry, such as oil spill clean-up. Patents on the construction of multi-plasmid strains capable of utilizing spilled oil have already been issued (in the United

States, the first is owned by the General Electric Company). Still, however, there is much room for numerous genetic improvement that can be made, particularly as to the construction of more efficient strains. Therefore, this is yet another fertile field of investigation for the Gulf region researchers with the potential for pay-offs in the short-term. The application of such strains could also be extended to their use for the clean-up and removal of residues in oil tankers and pipelines.

Considering the impacts of advanced biotechnology and genetic engineering in this area of application and its potential for a significant increase in oil production and decrease of recovery costs, coupled with more economic and efficient technologies for pollution control, science and technology strategists in the Gulf countries ought to consider the channelling of more resources to R+D programmes designed particularly to provide for the better understanding of the biochemical and physiological characteristics of microorganisms already present in oil reservoirs and the development of those that can degrade the less useful components of oil. This will include studies on plasmid engineering and the use of recombinant DNA methods for assembling needed biochemical pathways for hydrocarbon degradation. Another important area of research is the screening of microorganisms for the production of surfactants and viscosity enhancers and decreasers.

In many of the Gulf region countries a situation exists where, on the one hand, there is available low-cost methanol while, on the other, these countries have to import fish meal and other natural proteins. Under these circumstances the production of SCP would seem to present a lucrative option for the local production of protein, in the process lessening the need for imports.

A jointly sponsored research programme by UNIDO and the Kuwait Institute for Scientific Research (KISR) is already underway. The programme is carried out in close co-operation with the University of Illinois (USA) which is to provide the advanced scientific inputs and training of KISR researchers. The programme will cover the biochemistry and genetics of methanol utilizing bacteria and the cloning of the methanol utilizing gene. Once methanol gene cluster has been mapped, it will be restricted to obtain the entire gene cluster and recloned in a high copy vector, which can replicate in large numbers in gram negative bacteria with high copy number. The introduction of these genes through recombinant DNA into a wild type of methylotroph may allow for the use of the engineered organism for the rapid utilization of methanol resulting in a faster rate of growth in a minimal methanol medium. As a result, the production of SCP may therefore be considerably enhanced.

(2) Agriculture

Stress Tolerance in Plants

Introducing agriculture to desert and arid areas has been a major challenge to many nations, governments and technocrats. A combination of heat, high salinity and pH combined in most cases with low water content in soils have proven to be grave obstacles against providing favourable conditions for plant growth and breeding. Genetic engineering can play a significant role in developing new varieties of agriculture crops suited for these conditions and its use could direct the future course of agriculture in arid and desert areas of the world. Most of the Gulf region countries will stand to greatly benefit from such developments, particularly as today a sizeable portion of their resources is directed towards the import of fresh food stuff and other agriculture products required for local consumption.

Gene transfer technology combined with the techniques of tissue culture, protoplast fusion and regeneration plants from a single isolated protoplast are now the efficient tools to devel p and grow a complete fertile and tolerant variety of crops suited for arid and desert conditions.

There are a number of plants that grow well in desert conditions, such as cactus. It is therefore possible that through the transfer of certain genes from these varieties to crop plants, or perhaps entire chromosomes or section of chromosomes, transferred through protoplast fusion, the means will be provided for such crops to grow naturally in desert conditions. It has been recently reported by some laboratories in Australia that their researchers have been able to come up with methods for more proper control of plant genes. Specifically, researchers were able to transfer the gene control region from a heat resistance plant by fusing it with the gene coding region of another crop. Through this process one was able to improve the condition of the latter plant to grow under hot conditions.

Attempts using the same techniques are now under way to generate plant varieties that produce their own insecticide. This goal may be achieved through transferring the gene coding segment from insecticide-producing bacteria to the control region of plant genes.

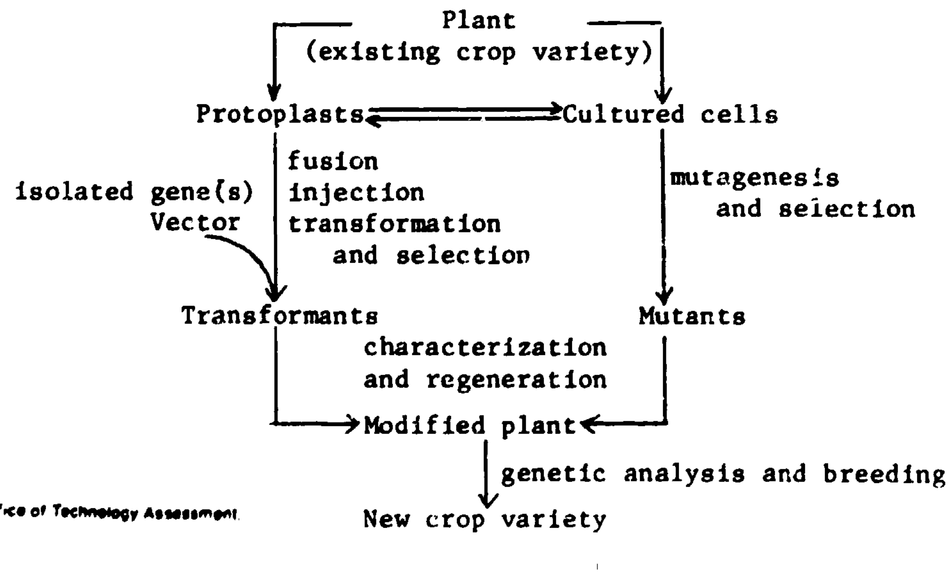
These fore-mentioned examples illustrate the multifaceted nature of advanced biotechnology, including recombinant DNA techniques, and its application in agriculture. Its demonstrated usefulness to other fields of agriculture such improvement for plants for nutritional contents and other crop improvement, i.e. nitrogen fixation, increased inherent photosynthetic efficiency, plant disease control, etc. are other examples of its far-reaching implication on agricultural growth in many developed and developing nations. It is more important to those countries which have suffered living in droughts and hunger stricken areas, to become more and more vulnerable to the politics of dependency in this struggle to eat.

The strategy for developing R+D programmes for the Gulf states should therefore include, but not be limited to, the following elements:

- studies on desert plants;
- selection of crop varieties;
- conventional plant genetics;
- methods to assemble the best genetic combinations utilizing reccombinant DNA techniques;
- selection of a limited number of crop varieties for a specific study.

Figure 1 demonstrates the method for generating a new plant variety by using advanced biotechnology.

Figure 1



SOURCE Office of Technology Assessment

III. The Role of the ICGEB in Supporting R+D Programmes in the Gulf States

One of the needs underlying the creation of the ICGEB is to provide concerted support for national efforts in developing countries to enable them to set up the necessary highly trained multidisciplinary teams of scientists and technologists in the fields of biotechnology and genetic engineering. Among the objectives of the ICGEB as outlined in its Statutes, is to "...stimulate and assist activities at regional and natinal levels in the field of genetic engineering and biotechnology". The ICGEB is also to act as the focal point of a network of affiliated (national, sub-regional and regional) research and development centres.

(a) Training

The importance of the ICGEB to be an independent institution for providing training opportunities to scientists from developing countries is one of the main features of its structure. The Centre's R+D programme has basically been designed to address itself to those problem areas most commonly shared by the majority of developing countries. Thus, trained scientists will return to their respective countries better equipped and well disposed to the application of these advanced techniques to help solve the unique problems of their nations.

The lack of highly qualified teams of scientists and technologists in the area of biotechnology and genetic engineering among the Gulf states has been, and remains, one of main concern of many policy makers in these countries. Recognition of the role of the ICGEB in building up such capabilities were illustrated through the excellent support the Government of Kuwait has provided to UNIDO's endeavour towards the establishment of the Centre. Kuwait thus became one of the first signatories of its Statutes in Madrid in September 1983. Other Gulf states are now giving serious consideration to their participation in the Centre.

(b) Joint Research and Development Programmes

The affiliated centres system (to date eleven member countries have officially announced their wish for one or more of their national institutions to become an affiliated centre to the ICGEB) embodied within the concept for the establishment of the ICGEB offers an excellent mechanism for interaction between regional and national R+D institutions and the Centre itself. Joint R+D programmes betwen an affiliated centre and the ICGEB could prove to be the optimum approach to provide efficient support to R+D programmes at national or regional level, as the case may be. The benefits are mutual as the affiliated centre would be able to share highly qualified expertise and know-how, including expensive and scarce equipment available at the ICGEB, while the latter will be able to expand its research opportunities.

Several situations may be envisioned where joint research is particularly appropriate. First, where an affiliate is performing R+D of interest to the region or nation it serves but lacks cf some of the required resources to carry it through, or encounters difficulties beyond its ability to handle. In these cases, the affiliate could call on the greater expertise and range of equipment inherent to the ICGEB. Second, results from R+D achieved at one affiliate may have to be scaled up at another affiliate, or the ICGEB, possessing pilot plant facilities and equipment. This expensive, specialized equipment may not be available at all affiliates. Third, the R+D carried out at the ICGEB may have to be tested under different field conditions as appropriate.

The above examples of ways and means the ICGEB can lend itself for supporting the development of the countries in the Gulf region are only illustrative and not exhaustive. The form and extent of such support would have to be shaped according to the unique requirements of each country, thus ensuring maximum benefits of the ICGEB to its constituencies.

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