Mexico

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RAMIREZ, RQ., and AGUIRRE, RLG. Mexico. In SORJ, B., CANTLEY, M., and SIMPSON, K., eds. *Biotechnology in Europe and Latin America:* prospects for co-operation [online]. Rio de Janeiro: Centro Edelstein de Pesquisas Sociais, 2010. pp. 150-170. ISBN: 978-85-7582-036-6. Available from SciELO Books <http://books.scielo.org>.

2.3. MEXICO

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Introduction

Biotechnology in Mexico is represented by a mixture of research and development as well as industrial and promotional activities realised at different levels of scientific and technological complexity. To evaluate its development and position in the country as well as estimating the potential and possibilities of technico-economic multi-lateral co-operation, it is necessary to define and delimit this techno-logical sector using the parameters available. The definition of biotechnology used in this document is as follows:

> A multidiscipline which has evolved from the initial objective of manipulating micro-organisms in the production of goods and ser-vices to include the use of enzymes, as well as vegetal or animal cells, aggregates or components thus amplifying its practical utilisation and now including the modification of superior organisms such as plants and animals. All this was made possible thanks to technological breakthroughs such as: recombinant DNA, cell fusion, cell and protein immobilisation, molecular synthesis with enzymatic characteristics which have all reinforced fermentation technology, culture of plant and animal cells and enzymatic technology(Quintero, 1985)

A classification of the different types of biotechnology is shown in Table 1 (González and Zermeño, 1986; Quintero, 1985). Based on these elements, the first part of this work presents a general view of the situation in Mexico describing the biotechnological activity in research and development, industry, vocational training and legislation.

In the second part, some potential options for technico-economic co-operation between the members of the EEC and Mexico are discussed within the framework of shared interests and equality of rights and duties.

Table 1. Categories of Biotechnology				
Parameter	*First generation*	*Second generation*	*Third generation*	*Alternative*
Age	Ancient	Modern	Modern	New Application
Scientific Content	Elementary and Advanced	Elementary and Advanced	Advanced	Elementary and Advanced
Technological Content	Elementary and Advanced	Advanced	Elementary and Advanced	Elementary
Type of organism or its part	Micro-organisms	Micro-organisms	Micro-organism Plant cell Animal Cell	Micro-organism
Origin of Organism	Natural	Natural	Natural Artificial	Natural
Type of product	Food, Chemistry	Food, Chemistry Health, Energy Agrochemicals, Contamination Control	Farming and Forestry, Food Chemistry, Health, Energy, Contamination, Control	Farming, Food Energy
Interaction with Socio-Economic setting and Environment	Control of nearly all variables that can be influenced	Control of nearly all variables that can be influenced	Control of nearly all variables that can be influenced The process is adapted to the setting	The process is adapted to the setting
Technology Users	Reduced and Intermediary	Reduced and Intermediary	Reduced, Intermediary and Intensive	Intensive
Range of Application	Growth Level of Demand	Growth Level of Demand Modification of Demand New System of Demands	Growth Level of Demand Modification of Demand New System of Demands	Growth Level of Demand Modification of Demand
Developed Applications	Simple	Simple Complex	Simple Complex	Simple
Source: González and Zermeño, 1986				

The Present Situation of Biotechnology in Mexico: Research, Development and Industry

FIRST GENERATION INDUSTRIAL BIOTECHNOLOGY

Industrial biotechnology of the first generation constitutes the most important category in Mexico in terms of market size. The main products are fermented drinks, milk derivatives, cereal derivatives, industrial yeasts for baking, alcohol (for industry or for consumption), acetic acids and edible mushrooms (Table 2). The most important application of this type of biotechnology is found in the fermented drink sector of which beer is the greatest user (González and Zermeño, 1986; Quintero, 1985)

Research and development in this biotechnological technique is scarce and production is oriented towards an internal market. Generally speaking, traditional Mexican biotechnology in the last decades has been in a state of saturation due to a sustained population growth with a better standard of living and because international trade has been of a marginal nature (González and Zermeño, 1986).

Despite the fact that there are different ranges of products, the traditional biotechnology industry is of a strongly oligarchical nature. The competition between these industries from one point of view and the actual maturity of technology from another, has led the stronger enterprises to rationalise and standardise production through more and more automated processes.

The most consolidated industries such as those for fermented drinks like beer, wine products and liqueurs are important sources of employment not only in production and distribution of these products but also of the raw materials, and are factors of economic development of other products. This industry has reached a state of prolonged saturation. Part of the industry handles high production volumes which helps improve product quality and productivity and which represent the most important conditions to maintain and improve the internal market as well as to enter into international markets (González and Zermeño, 1986).

Table 2. **Mexican Biotechnological Industry**		
Category	*Products*	*Companies*
First generation Biotechnologies	Beer	Cervecería Modelo Cervecería Cuahutemoc Cervecería Yucateca
	Wines and brandies	68 companies
	Derived products and milk products	431 companies
	Yeast for bakeries	Acidos Orgánicos, S.A. Industria Mexicana de Alimentos, S.A. de C.V. Fleischman
Second generation Biotechnologies	Ethyl alcohol	Asociación Nacional de Productores de Alcohol
	Acetic Acid	Compañia Beneficiadora Del Coyol, S.A.
	Antibiotics	Fermic, S.A. de C.V. Orsabe, S.A. Cyanamid de México, S.A. Pfizeer, S.A. de C.V. Centro Industrial Bioquímico, S.A. Upjohn, S.A. de C.V. Abbot Laboratorios de México, S.A. Sinbiotik, Beneficiadora e Industrializadora, S.A.
	Enzymes	Enmex S.A. Velfer, S.A. Pfizer, S.A. *Genín, S.A. de C.V. *Enzymóloga, S.A.
	Amino acids Organic acids Bio-fertilisers	Fermentaciones Mexicanas, S.A. Química Mexicana, S.A. Pfizer, S.A. Nitragin, S.A. Diamond Shamrock Pagador Química Lucava

Table 2. **Continued.**		
Category	*Products*	*Companies*
Second generation Biotechnologies	Vaccines	Gerencia General de Biológicos y Reactivos Laboratorios Dr. Zapata Other companies**
Third generation Biotechnologies	Micro-propagation	Biogenética Industrial, S.A. Mexicana de Propagación de Plantas
Alternative Biotechnologies	Methane	Digestors exist in various parts of the country
	Silage	Various parts of the country
	Cell usage	Various parts of the country

* Dedicated to technological development.
** Dedicated to the final packaging.
Source: Quintero, 1985

Such increments in quality and productivity could be achieved by small technological innovations. These are likely to take place in the near future since a number of fermented drink manufacturers have shown an interest in national research groups working on solutions to service problems in the industry.

The consumption of food products such as edible mushrooms and milk derivatives can be increased by encouraging lower cost and smaller scale production processes than those predominant in the country.

The culture of mushrooms and other macro mycological products can be developed both for export and internal consumption at production sites that make use of favourable climatic conditions and by intensively using manpower (Leal, 1985).

It must be emphasised that the production of edible mushrooms constitutes one of the rare possibilities of biotransforming lignocellulosic residues without submitting them to a pre-treatment which is presently still very expensive. This is of great importance because of the abundance of this type of residue in the country (Table 3) (Leal, 1985).

The production of macro mycological products with this approach requires that the culture technology is adapted to the local conditions from the point of view of both availability and investment as well as cost and skill of local labour. The same applies to the development of new methods for the preparation of substrates from local raw materials, new types of materials and locally adapted climatisation (Leal, 1985).

Table 3. **National Agricultural Production in 1978 (NPTSD, 1984)**	
Agricultural harvest	*Production (tons)*
Corn straw	16.613.532
Sorghum straw	2.492.874
Wheat straw	1.723.670
Bean straw	1.320.716
Sugar cane straw	1.205.557
Wheat husks and brans	750.172
Barley straw	534.746
Oat straw	131.321
Non-commercial fruit and vegetables	79.855
Rice husks	59.309
Peanut straw	43.379
Chickpea straw	25.134
Total	24.980.265
Source: Leal, 1985.	

Milk derivatives such as traditional cheeses can be integrated into the production of milk, which in turn forms part of the normal agricultural production, through fermentative processes using the subproducts or the excesses as forage. This improves the profit of small producers and reduces competition in the production of the basic grains which form the popular diet (Viniegra, 1986).

The above implies the availability of specialised equipment, technical assistance and a means of commercialisation for the small cheese co-operatives. These services are necessary to encourage and sustain the production chain at an elementary technological level and include information, transport and distribution methods in order to commercialise the products in a way adapted to the local conditions (Viniegra, 1986).

Second Generation Biotechnology

This type of biotechnology is actively used in the production of antibiotics, amino-acidic enzymes and in the treatment of effluents as shown in Table 2. All the technology used comes from abroad (González and Zermeño, 1986).

A well equilibrated investment in this category of global bioindustries does not apply to groups of products in the same way. For this reason foreign investment appears to dominate the area of enzymes and certain antibiotics. However, there are national and public enterprises which are dedicated to the production of amino acids as well as penicillin and some of its derived products (Quintero, 1985).

Because of the international effervescence in biotechnology a number of new, mostly small sized, national enterprises have appeared in this biotechnical category (Table 4). It must be emphasised that newly created enterprises have a more open attitude towards research and development contrary to the vast majority of second generation biotechnological enterprises in which this type of activity is almost non-existent.

Table 4. **New Biotechnological Organisations in Mexico**	
Enzymology (Monterrey, N.L.)	Phenylglicina (enzymatic), phenylacetic acid, phenylalanine and aspartame (of its interest)
Bioenzimas (Saltillo, Coahuila)	Improved grains, insecticides, gibberellic acids and other agricultural biotechnological products (enzymes)
Industrial biogenetics (México D.F.)	Micropropagation of strawberries, aspergus, Violet (tissue cultures)
Genín (México D.F.)	Technological development of immobilised enzymes
Forestal Center of Genetics (Texcoco, Edo of México)	Genetics improvement and forest micropropagation
Source: Quintero, 1985	

Research groups are concentrated in universities, centres and institutions of higher education (Table 5). It is in this type of biotechnology that the country has the largest and most qualified research group even if most of its efforts are devoted to applied research and technological development. However, no technological development in this area has been applied to production methods (González and Zermeño, 1986; Quintero, 1985).

In the case of enzymes and new pharmaceutical products the internal market is insufficient and the competition in international markets is very difficult. With amino acids, the important conditions for industrialisation exist but expansion presents problems with economic resources. This type of problem also affects the unicellular proteins and the microbial polysaccharides. In the case of xanthans, for example, the technology has developed in this country and has reached a semi-commercial level with a specific application for the product. However, at a national level, there are insufficient economic resources to make use of it even if it shows a high profitability in the current conditions in Mexico (González and Zermeño, 1986; Quintero, 1985).

***Table 5*. University Research Centres with Adequate Facilities and Experienced Staff**
Genetic and Biotechnological Engineering Research Centre (UNAM), Cuernavaca, Mor.; covers an area of 5.000 m². Areas of interest: genetic engineering and biotechnology applied to health and food.
Research Centre for nitrogen fixation, (UNAM), Cuernavaca, Mor.; covers and area of 4.000 m². Areas of interest: molecular biology and genetic engineering applied to plant cells.
Research and Advanced Studies Centre, (IPN), Department of Biotechnology and Bioengeering, México, D.F.; has an excellent pilot project facility and well equipped laboratories. Areas of interest: fermentation and enzymatic engineering.
Research and Advanced Studies Centre. (IPN), Unit of Modern Plant Biology, Guanajuato, Gto; covers and area of 8.000 m². Area of interest: conservation and preservation of grains, genetic engineering applied to plant cells.
Research Institute of Biomedicine, (UNAM), México, D.F.; has an operational pilot project and is generally well equipped. Areas of interest: industrial microbiology, fermentation and enzymatic engineering.
Department of Biotechnology, UAM – Iztapalapa, México, D.F., has pilot project facilities and good equipment. Areas of interest: food, transformation of substrates via solid fermentation, water treatment.
Source: Quintero, 1985

Other countries show a great interest in acquiring this technology. This could be very positive for national production to increase its confidence in the local development and the resources obtained from royalties could be used to finance national developments.

The lack of economic resources is critical within all categories of biotechnology but particularly for second generation types as, even if they have rapidly restricted themselves, they offer better short term possibilities because of the world wide scale of development (González and Zermeño, 1986; Quintero, 1985).

THE NEW OR THIRD GENERATION BIOTECHNOLOGY

Micro-organism manipulation work is exclusively restricted to research in centres and higher educational institutions. It is currently being linked with industrial projects especially for the improvement of pharmaceutical processes.

It must be emphasised that pharmaceutical products form the objective of the majority of research projects. They are internationally highly competitive with high development costs and require a long time before commercialisation. Such projects are: human insulin, growth hormones, some vaccines, diagnostical tests, interferons, etc.

There are many qualified research groups in the field of plant cells, particularly cultures of plant tissues (CVT), in the country which, although they presently work on micro-projects, could devote their work to topics of importance in the agricultural sector. Two of the recently created enterprises belong to the plant biology area which covers the technologically less sophisticated aspects of CVT such as the micro-propagation (González and Zermeño, 1986; Quintero, 1985).

The genetic engineering of plants is becoming a well structured sector. A centre has just been opened and what is most important is the integration of very high level human resources. For animal cells the human and technical resources are scarce compared with the previous sectors and they are mainly dedicated to the development and industrial production of vaccines against measles and poliomyelitis but with some work on embryo transplants at a commercial level.

These elements, even if briefly presented, allow the following prospects for third generation biotechnology to be considered.

MICRO-ORGANISMS

This sub-category could have an important role in the improvement of micro-organisms both for known second generation processes and for future modifications to processes used in the manufacture of existing products. Both cases link the existing research groups in the country and firmly localise their participation in the chain of complete biotechnological processes. The second option requires an understanding of the present productive methods and capacity in the technologies which are intended to be substituted (González and Zermeño, 1986).

New products, and particularly pharmaceutics, have greatly reduced prospects as the human and economic resources (especially the latter) are limited and the risk involved in new developments is very high.

PLANT CELLS

Simpler applications such as micro-propagation of 'cultivares-valiosos' have a considerable potential market because highly skilled scientists are available to develop the techniques and, if moderately skilled technicians are trained, the use of the available climatic conditions, the market access and the cost of labour will enable the country to both compete with external markets and open new markets. Also, the economic resources required to make use of these productive activities are not excessively high compared to those required by other types of developments (González and Zermeño, 1986; Robert, 1985).

The production of 'metabolites secundarios' using plant cells in biological reactors for the processing of raw materials of for agricultural, food and pharmaceutical products is a sector in which highly skilled scientists are available but in insufficient number to cover all the stages necessary for complete technological development. Moreover, an adequate infrastructure is needed to allow development to be taken beyond the laboratory stage (González and Zermeño, 1986).

There are, however, important limitations related to the type of products. For example: the development of new pharmaceutical products is very expensive, very long, and involves many risks. The production of natural substances for food use, such as flavours, aromatics and colorants is less costly and faster than the previous processes but experiences high international competition which demands a very careful selection of development projects.

Without any doubt the most important potential application related to plant cells is a genetic improvement. Both in Mexico and internationally, agricultural production currently faces a series of limitations which are: a lack of cultivable land, environmental stress, sickness and plague (González and Zermeño, 1986; Robert, 1985).

For each of these limitations, plant biotechnology has an answer which could be the development of varieties adapted to ever better controlled conditions (which is not much different from the 'green revolution') or varieties more and more adapted to socio-economic and environmental conditions. This type of answer could revolutionise agricultural production, have large repercussions on industry and the economic and social activity of each country. This would particularly apply to those less industrialised countries which, for their development requirements and the diffusion of this kind of technology, could have access to the benefits that the latter could relatively easily provide (González and Zermeño, 1986; Robert, 1985).

In the particular case of Mexico, the conditions allow both solutions to be applicable. There are highly qualified scientists available who can develop either of the technological solutions. The food policy adopted will determine which solution will be emphasised (González and Zermeño, 1986)

Before ending this topic, it is very important to note that genetic manipulation research groups are aware that they do not replace the traditional work of agronomists and botanists. For this reason, a contact with them is being sought and mechanisms are being pre-pared to promote interdisciplinary research.

Finally, the existing animal cell groups, even if very scarce, have extensive experience in producing vaccines and they have recently succeeded in using a national development for the industrial production of anti-measles vaccines with diploid cells and are actively working to modify the production of polio vaccines (the diploid cells instead of monkey renal tissues). The experience of these groups forms an excellent basis for the promotion of this sector especially for the improvement of processes.

ALTERNATIVE BIOTECHNOLOGY

Less conventional biotechnologies, which try to use residues in order to produce biogas or cattle feed, should also try to solve the problems of regional contamination caused by specialisation in cattle and agriculture. However, the scale of production must be maintained in order to reach intermediary dimensions. To presume that these biotechnologies exist in the rural environment only at the level of one or several families is very optimistic (González and Zermeño, 1986; Quintero, 1985).

From this viewpoint, alternative biotechnology is better considered as a subcategory of all other biotechnologies rather than a separate category in which its scope of application would be very limited and the technological content more basic (González and Zermeño, 1986; Quintero, 1985).

Based upon previous success, the development and growth potential of certain biotechnologies applied to aquaculture, the cultivation of mushrooms or other species and food processing will be stimulated as conventional technology is more compatible and the impact much greater. What is most important is to acquire experience and create a basis to be able to benefit from the possibilities offered by biotechnology. This also means a change in the tendency towards specialisation. As long as diversity is increased by more integrated processes which are less intensive in capital and energy and more adapted to the environment, the profits related to the scale of production will be less and less important and the level of development of the country will be raised with less socio-economic and environmental costs than the current mode of development (González and Zermeño, 1986; Quintero, 1985).

Vocational Training

The history of scientific training in biotechnology in this country dates back to the second half of the thirties at the time when the studies of enzymology and biological chemistry were created and oriented towards industrial biological processes. Both studies later became biochemical engineering (1957). Nowadays, a degree in biochemical engineering can be obtained at more than twenty educational institutions distributed throughout the country (Quintero, 1985, 1986).

Postgraduate training began early in 1970 and the seven institutions which offer such courses are fisted in Table 6. All offer master of science degrees and, recently, two of them offer doctorates. Most of the postgraduate programmes cover the most general sectors of biotechnology (fermentation and enzymatic technology, genetics and genetic engineering) and two are dedicated to plant biotechnology. At first degree as well as at postgraduate level the main subjects are oriented towards the food sector without particular specialization (Quintero, 1986)

***Table 6*. Postgraduate Biotechnology Programme (Leal, 1985)**

No.	Institution	Programme	Degree
1.	Research and Advanced Studies Centre/D.F.	Biotechnology	M
2.	Research and Advanced Studies Centre/D.F.	Biotechnology	M
3.	Research and Advanced Studies Centre/Irapuato	Biotechnology	M, D
4.	Technological Institute of Mérida/ Scientific Centre of Yucatan	Biotechnology	M
5.	Technological Institute of Veracruz	Biotechnology	M
6.	Technological Institute of Veracruz	Biotechnology	M
7.	Research Institute of Biomedicine, National Autonomous University of México	Biotechnology	E, M, D

E = Technical training
M = Master's degree
D = Doctorate
Source: Quintero, June 1986.

Historically, vocational training in biotechnology has only covered biochemical engineering with postgraduate degrees in biotechnology and bioengineering but the available number of positions related to biotechnology is much higher in the country. In plant related biotechnology there are more than 100 higher education establishments for agriculture and biology with an equal number of experimental sectors.

There are several institutions which offer a master's degree in a speciality linked to biotechnology and which have had doctorate programmes in biochemistry, cellular and molecular biology, genetics, microbiology, chemistry and biology. Moreover, since the Mexican government considers biotechnology as a priority sector, it assigned special resources for all of the scholarships granted in 1985 for postgraduate study abroad by the National Council of Sciences and Technology (NCST) of which 17% corresponded to biotechnology.

The basis of the above indicates that degree level training in biotechnology is actually based on the possibilities of absorption by the existing biotechnological industry which requires technicians of an average level of education. In the case of the first generation, the specialised technical assistance is obtained from abroad through suppliers of machinery and equipment; in the case of the second, most enterprises are branches of multinationals which import this technical assistance and, as far as both the third and alternative ones are concerned, they are non-existent. (González and Zermeño, 1986).

Finally, at postgraduate level, the system is new and has produced in the last ten years more than twenty master's degrees in sciences and more than forty without any degrees. An exhaustive diagnosis was recently completed in the food sector in which biotechnology is included for practical reasons. As a result of this work, specific recommendations have been made for each of the postgraduate programmes in the country relating to food with the expected result being a sharp increase or development in the short or middle term of this level of biotechnology. Relative to this, it is important that scientific training at a national level must be directed towards the interdisciplinary work and to the development of integrated biotechnological processes through educational programmes and research linked to the production sector (VTG, 1985).

Legal Aspect

The country's legal requirements relating to technological and economic multilateral cooperation are: patent and trademark laws, laws relating to registration and control of technological transfer and those concerned with foreign investment.

The patent and trademark law dates back to 1976 and has recently been reformed and expanded partly in dose relationship with biotechnology. According to Mexican law the following are not subject to patents:

1. The plant and animal species, their varieties, and the essentially biological processes necessary for their creation, including those of a genetic type.
2. The biotechnological processes for pharmaceutics, general medicines, drinks and food for animal consumption, fertilizers, anti-plague products, herbicides, fungicides or biologically active products.
3. Chemical products, chemico-pharmaceutics, general medicines, food and drinks, food for animal consumption, fertilizers, herbicides, fungicides and biologically active products.
4. Food and drinks for human consumption as well as processes to obtain or modify them.

According to the present Mexican legislation, a patent does not cover biotechnological processes and products; however, it is possible to obtain a certificate of invention for processes and products mentioned in paragraphs b) and d).

The invention certificate is a non-exclusive right granted by the Mexican State for a period of 14 years to allow the holder to commercialise an invention. Anyone else who is interested in commercialising the product pays the certificate holder the corresponding duties. This certificate is used when a patent is not granted because the invention is of social benefit where a monopoly is not permitted.

The invention certificate allows royalty payments to be made even if it is not possible to practically apply the invention because it does not oblige the exploitation of the invention.

This is not the same with a patent where exploitation of the invention should start within three years from the date of it being granted. If it is not exploited, the patent becomes invalid and the invention becomes part of the public domain.

Mexican law states that one can register a certificate of invention concerning any invention susceptible to be protected as a patent. This has been done to give an incentive to individual creativity via advantages and to protect the rights of research and development workers who are concentrated in universities. If the only means to protect their inventions was through patents, they would lose their rights if they did not manage to exploit them within a three-year period.

Technological transfer in Mexico is regulated by laws covering the control and registration of the transfer of technologies and the use and exploitation of patents and trademarks (LCRTT). The main objective is not exclusively to maintain control over technology transfer but also to ensure that its own technological work is promoted. The organisation responsible for the enforcement of this law is the Secretariat for Commerce and Industrial Promotion (SCIP), which controls the National Register of the Technological Transfer (NRTT).

Item 2 of this law catalogues the legislation used within the national territory where registration is compulsory. Those related to technical and economic multilateral co-operation in biotechnology are presented in Table 7. These acts or agreements are covered by Mexican laws, by treaties or international agreements of which Mexico is part and which are applicable to the case.

Table 7. **Licences, Contracts and Activities Related to the Multilateral Co-operation in Biotechnology that have to be registered with the 'RNTT'.**
– Licence for use or authorization for improvement or exploitation of an invention which is patented or covered by an invention certificate.
– Licence or authorization to use commercial names.
– Communication of technical knowledge through plans, diagrams, models, instructions, specifications, personnel training and education or any other means.
– Technical assistance of any type.
– Provision of basic or detailed technical assistance.
– Operational services or company administration.
– Advising, consulting and supervising services if controlled by foreign nationals, or their representatives, independently or their residence.
– Computer programs.

The following are required to apply for registration with the NRTT: Mexican nationals as well as foreigners living in the country, foreign agencies or foreign branches established in Mexico as well as nationals residing outside the country but who are involved with agreements or contracts which affect the country.

Registration is necessary to be able to benefit from the profits, the encouragements, the assistance or the facilities foreseen in the governmental plans and programmes, as well as for the establishment or expansion of industrial enterprises. The legislation contained in article number 2 which has not been registered with the NRTT (or which has been cancelled by the SCIP) is null and void and cannot be made valid in front of any authority and its application cannot be requested by the national courts.

The law also provides a chapter covering the causes allowing the NRTT to reject an application for the following reasons: the protection of the applicant regarding any detriment to his financial situation, his administrative autodetermination or any restriction to his R&D activities.

Within the legal framework, and in policies directly related to foreign investment, the law enforced since 1973, which promotes Mexican investment and regulates foreign investment, together with the policy of

selective promotion of foreign direct investment, which started in 1984, clearly promotes the direct foreign investment in biotechnology. From this viewpoint, it is important to note that one of the most regulated foreign investment sectors, that of secondary petrochemical derivatives, has recently been freed from the restriction of using national capital for the majority of investments relating to the expansion of the range of products. Current technological advances (including biological technology) have made this possible using either different processes or raw materials which are not petrochemical. In Figure 1, the percentage participation of foreign direct investment is presented according to the country of origin.

Options for Technico Economic Co-operation

Biotechnology has direct applications in most of the sectors of economic activity and can be used at different scientific and technological levels with a variety of raw materials for similar types of products. This results in a group of technologies with different characteristics and requirements and with a tendency for interchange between them. The countries meeting on this occasion are all at different levels of technological advancement. For this reason it is important to consider any proposal related to these differences and this is why the possibilities of application of the various options are closely related to the scientific and technological capacity of the participants and to the level at which their political, economic, and social interests can merge.

1984	*%*	*1985*	*%*
United States	66,0	United States	67.4
Federal Republic of Germany	8.7	Federal Republic of Germany	8,0
Japan	6.3	Japan	6.1
Switzerland	5,0	Switzerland	5.3
Others	14,0	Others	13.2

Sources: SCFI, 1986

Fig. 1. Foreign investment per country of origin (percentage)

It is important to underline that, in Mexico, studies have been made for some time to define the sectors which require efforts to be made to develop and diffuse biological technology whilst taking into account the requirements, the scientific and technological capacities, the economic resources and the availability of raw materials (González and Zermeño, 1986; Quintero, 1985, 1986).

The establishment of priorities was no easy task for a country with the population size of Mexico. However, it has become apparent that the multitude of applications made possible by biotechnology cannot be coped with simultaneously. Accordingly the applications selected for a recent study on the evaluation of opportunities in biotechnology, which was financed by the National Council of Science and Technology, are: food, agriculture and health (Quintero, 1985, 1986).

Taking into account the above factors and other elements considered as important for the scientific and technological policy of the last 15 years in order to make sure that research has an economic and social impact, (NPTSD, 1984; NPST, 1978) as well as the situation concerning biotechnology, (Quintero 1985) we consider that the following types of co-operation are the ones which would have the greatest potential for success.

Vocational Training

High level technical training is mainly oriented towards interdisciplinary education and research programmes which integrally cover the different stages of the development process of biological technology. The sectors which should be mostly emphasised are: design, sizing and operation of biological reactors as well as recuperation and purification of products. This type of training should preferably be given in research laboratories of the production sector as well as in technological development centres.

Research and Development

R&D collaborations should be aimed at the realisation of research projects in previously mentioned applications. The possibilities offered by biotechnology for the co-existence of differing levels of technology would allow different countries to participate in precise activities throughout the project according to their respective scientific and technological capacities. As a consequence, third generation and alternative biotechnology provide several applications in which the processes must be adapted to socio-economic and environmental conditions, and in which some of the stages of the project must be realised at the site of the application.

To take care of this, the country has provided research and technological development centres with experience in pilot and commercial level projects allowing specific agreements of collaboration to be agreed. Some of these centres have highly qualified staff who belonged to international research groups at the time these groups were realising considerable achievements in third generation biotechnology.

Applications in Production

Establishment of new undertakings in selected applications. The most appropriate option for multilateral co-operation is considered to be joint ventures as this would imply an intermediate investment level compared to the establishment of a branch and the financial risks would be shared.

This option not only allows the partners to share the technology, but also offers the possibility of gathering together human, technical and material resources to continue with research and development activities. In our opinion, this is very similar to previous statements that multilateral co-operation should be founded on shared interests and in a mode of equality of rights and duties.

Finally, the options for co-operation that have been mentioned in the case of Mexico should be based on third generation and alternative biotechnology. The advantages and the disadvantages of the analysis of some of these options is shown in Table 8.

***Table 8*. Types of Associations for the Production Sector.**

Type	*Advantages*	*Disadvantages*
Association via licence	Cost and risks are low for the technological partner. Greater control for the financial partner	Financial profits limited for the technologist Risk that the technology is not adequate for the socio-economic and environmental conditions
Joint ventures	Shared financial risks Access to patented technological information. The optimization of resources to develop new technologies. The access to reputation, market distribution network and knowledge of local culture.	Whatever disadvantages remain after defining the following: – Proposals – Objectives – Contribution of each party – Adequate methods to evaluate tangible and intangible assets

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