Biotechnology in Chile (Overview)*

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This article provides a brief overview of biotechnological activities in Chile. The role played by the scientific community is emphasized and aspects of technology transfer are commented.

Key words: *biosafety, bioleaching, biotechnology, Chile, diagnostics, environment, human genome, industrial, marine, plant*

Located in South America along the west side of the Andes, Chile has a total land area of 756,945 km^2 excluding its Antarctic territory. With a human population of 13.5 millions, its estimated GNP for 1993 amounts to US$ 44 billions. In proportion to its size and degree of development, Chile has not been indifferent to the advent of modern biotechnology. As it happened in other countries, its early manifestations took place at the universities, where the techniques of recombinant DNA, plant tissue culture and monoclonal antibodies were introduced in the early eighties. Due to the product-oriented character inherent to biotechnology, several concerns spontaneously arose among scientists working at academic institutions: To what extent was it proper for a university to commit itself to biotechnical activities? If it was, would the university have to deal not only with research, but also with development, manufacturing and commercialization of products? Should applied research or research contracts with industry be favored? How should scientists relate to industry in general and to possible new biotechnology companies?

In order to analyze these issues, still valid for academic institutions throughout the world, some of the best known Chilean universities appointed biotechnology committees. Typically, these were composed of professors from the Faculties of Biological and Chemical Sciences, Medicine, Engineering and Economics. Soon it became evident to these committees that the best strategy for supporting biotechnology was to foster scientific research in areas that could later have biotechnical applications. Research projects were proposed in each institution, with the participation of scientists from different departments or even from different universities. These committees have had variable degrees of relevance at their universities and some of them are still active.

In 1983, an event took place in Chile that had a strong impact on the consolidation of biotechnology at a national level. The scientists themselves decided to create the National Committee of Biotechnology (NCB). In the early years, this Committee was unofficially hosted by CONICYT, the National Commission for Scientific and Technological Research. Later, in August of 1987, the Committee was officially assigned the task of advising CONICYT in matters related to biotechnology. One of its first measures was to define specific fields of interest, considering both the existence of the various research groups at different institutions, as well as the

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economic activities that could benefit from biotechnology. These fields were: mineral leaching, nitrogen fixation, plant tissue culture, anaerobic digestion of biological waste, diagnostic kits for human, animal and plant diseases, microalgal culture, industrial enzymes, embryo manipulation, human genome and lignocellulose. A subcommittee was also appointed to each field. Some of these have been very active, holding periodic meetings, workshops and other activities. Some have also conducted large research projects that have allowed a fruitful interaction among their members.

Last year, the aforementioned fields were reorganized into four large areas (Table I), and two new areas were added: environmental biotechnology and biosafety. Due to the lack of regulations in Chile, the Committee considered it necessary to appoint a group with the purpose of defining some criteria on biosafety. After two years, this group submitted a document dealing with, among other matters, concepts and objectives of biosafety, recommendations for the handling of pathogenic microorganisms and experimental animals, for working with techniques of recombinant DNA, etc. It is expected that research groups in the country will soon become familiar with and will adopt these criteria.

To date, the NCB has organized three national meetings, in 1989, 1991 and 1993, with the participation of 250, 400 and 350 scientists, respectively.

The NCB has also been the official link between Chile and international organisms that promote collaboration among nations. Thus, the Committee is responsible for Chile's participation in the Regional Program of Biotechnology for Latin American and Caribbean countries sponsored by UNDP/UNESCO/UNIDO, as well as in the UNIDO-sponsored International Center for Genetic Engineering and Biotechnology (ICGEB). The Committee selects research projects submitted by Chilean groups to these institutions, suggests candidates for international training courses, selects the courses given in Chile eligible for international funding and promotes the visits of foreign biotechnologists. To date, several research proposals, all of them involving international collaboration, have received support from either institution. For example, the Regional Program financed a total of nine projects, eight of which involved Chilean research laboratories. These dealt with enzymatic degradation of agroindustrial waste, potato resistance to virosis, enzymatic hydrolysis of lactose, genetic transformation of corn and sugar cane, diagnosis of human and of plant diseases, and massive production of monoclonal antibodies. The latter encouraged interaction among groups from twelve Latin American countries. In turn, the Collaborative Research Program from ICGEB has received grant applications from fourteen different countries worldwide. Among them, Chile ranks second in terms of projects funded. These are in the fields of bioleaching, lignocellulose degradation, development of diagnostic systems, plant tissue culture and wastewater treatment. Courses, symposia and workshops recently held in Chile and sponsored by these organizations illustrate the magnitude of their support. They included a workshop called "Aquatic biotechnology and perspectives for Latin America", the "Fourth Latin American course of biotechnology" and the "Santiago Southern Summer Symposia". In previous years, the Regional Program sponsored the symposium "The Industry-University interaction and the development of biotechnology in Latin America" and also the international workshop "Molecular genetics

TABLE I

Areas of interest defined by the National Committee of Biotechnology

Area I:	Marine biotechnology Environmental biotechnology Animal embryo manipulation
Area II:	Plant biotechnology Wood and lignocellulose biotechnology
Area III:	Human genome Diagnostics Biosafety
Area IV:	Industrial enzymes and fermentations Bioleaching

and the human genome project: perspectives for Latin America", contributing in this case with the participation of 24 visitors. A third organism that has been supportive in this sense is COBIOTECH, the Scientific Committee for Biotechnology of ICSU, not only through its co-sponsorship of activities held in Chile, but also through the organization of meetings elsewhere, which Chilean scientists have attended.

For a country to be competitive in biotechnology, two basic requirements need to be fulfilled: it must possess a strong research base and, at the same time, it must have the industrial capacity to convert the new findings into commercial products. The number of projects financed by FONDECYT, the National Fund for Scientific and Technological Research, provides an idea about the first requirement. Yearly, FONDECYT finances about 1,000 projects. On the average, 50 of them, a rather small number, could be considered to fall within some field of biotechnology. However, in spite of this reality, it is likely that Chilean universities have a capacity to respond to demands from industry that is presently not being utilized. This situation, in itself paradoxical, is even more so considering that most of Chilean exports are based on the exploitation of natural resources, such as forestry, mining, agriculture, fishing, etc., all of them susceptible to biotechnical approaches.

Several reasons may account for the above. One of them could be that most people from industry do not realize the benefits offered by biotechnology. Another one has to do with the lack of links between industry and academia. Most projects originating from University laboratories are conceived on the basis of their originality and academic rigor, rather than practical applications that may be derived therefrom. Some mechanisms to facilitate the interaction of scientists with industry have been implemented. The main one is called FONDEF, a Spanish acronym for Fund for Scientific and Technological Development. This program is aimed at improving R&D in high priority areas and promoting technology transfer from the research institutions to the productive sector. FONDEF is presently funding 23 projects related to biotechnical applications, with a total cost of US$ 25 millions, 15 of which are provided for by FONDEF, 3 by industry and 7 by the different universities and institutes involved (Table II). These projects cover subjects such us effluent treatment, biosensors, transgenic plants, industrial fermentations, genetic improvement of forest species, agriculture in desert zones, pulp biobleaching and food biotechnology. FONDEF is also supporting the establishment of a center that will offer services in protein and nucleic acid synthesis and sequencing, and sequence analysis.

In Chile, there are still few companies based on the new biotechnologies. Two of the most important ones are Bios Chile and Bioforest. The former was founded in 1986 and it presently does research, development, production and commercialization of products for human and animal health. Among its products that are already in the market are several diagnostic kits based on monoclonal antibodies. At the same time, programs for the production of hormones and vaccines are in an advanced stage. Having strong links with American and European companies, Bios Chile sells its products both in Chile and abroad. In turn, Bioforest was founded in 1990 as a joint venture between the largest forest company in Chile and a Swedish company. Located in the southern city of Valdivia, its main objective is to make use of new biotechnology in order to improve the yields of the various forest owned by the company. Current programs in Bioforest include several approaches for

TABLE II

Projects in various fields of biotechnology supported by the FONDEF program, organized according to the areas defined by the National Committee of Biotechnology

Areas	# projects	Budget (US$)
I	6	6,862,541
II	10	12,204,912
III	3	2,032,304
IV	4	4,535,670
Total	23	25,635,427

micropropagation of eucalyptus, pine and native species, as well as biocontrol of pests. Besides these two companies, there have been also a couple of unsuccessful startups, which seems to constitute a common situation in this type of enterprise. On the other hand, traditional companies are slowly innovating with new processes. For example, two copper plants representing an investment of US $ 600 millions will soon start operating utilizing exclusively a bioleaching technology developed ten years ago by the local Pudahuel mining company; a baker's yeast producing company is developing a microbial pigment for salmons; the pulp and paper industry is evaluating the use of enzymes for pulp bleaching, etc.

These examples, although few, are encouraging. However, the best reason to be optimistic is that more people outside the scientific community are becoming aware that biotechnology constitutes a suitable alternative that will contribute to lever Chile's economic development.