BIOTECHNOLOGICAL ACTIVITIES OF THE MIRCENS – HISTORY, TRAINING AND RESEARCH UNTIL 2002

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[This chapter is a compendium of reports of historical importance from the MIRCEN-Directors and the ASM-organized MIRCEN-Director Meeting 2002, which was attended by E.J.DaSilva in Memory of Edgar DaSilva, former Director of Life Science Division in UNESCO and Founder of the MIRCENs]

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Summary

The harnessing and tapping of the vast invisible reservoir of microbial diversity influence the development of new bioindustrial and environmentally friendly processes. The transformation and translation of innovative research with microorganisms contribute to the development and the use of clean technologies, to the management and conservation of the environment, and to the market-oriented products such as biofuels, biomedicine, biopesticides and bioremediants.

The global MIRCEN network is an on-stream worldwide resource that reflects the inherent mechanism of flexibility as well as the triangle of research, education and development. As can be seen below, it tackles issues of intellectual property and bioinformatics, and strengthens the research function of education through cost-sharing funding responsibilities and fostering quality infrastructure in an academic environment.

The UNESCO MIRCEN-ASM collaboration over the last 20 years was comprised of a joint ASM/UNESCO research fellowship scheme, an ASM/UNESCO resource persons program, and UNESCO support to the ASM Global Outreach program. These programs were responsible for providing opportunities for young scientists to develop their research interests and to obtain expertise in advances in the field of microbiology

1. Introduction

Welcoming address by E.J.DaSilva to the MIRCEN-Directors Meeting which was organized by ASM in 2002: The MIRCEN network, embodied in your presence here today, has emerged from a pilot network of some eight to ten nodal research and training laboratories on the five continents, into a global infrastructure that involves over 30 national, regional, and international centers in 26 countries. These centers are devoted to the mission of conserving, managing, distributing, and utilizing the diversity of the microbial gene pool for the benefit of humankind. Also, there is no doubt that the network of microbial resource centers plays an important role in the evolution and transformation of *global village microbiology* into today's *global class of biotechnology*.

The scientific output of the MIRCEN network of academic institutions and universities are many, and result from working together with:

1. UNESCO National Commissions, e.g., the Japanese and French National Commissions for UNESCO;
2. UNESCO Field and Liaison Offices, e.g., the UNESCO New York Liaison Office;
3. UN agencies: the Food and Agriculture Organization (FAO), World Health Organisation (WHO), the United Nations Industrial Development Organization (UNIDO), and the UN programs such as The United National Development Programme (UNDP) and the United National Environment Programme (UNEP);
4. Governmental bodies, e.g., the Organization of American States (OAS), and the [biotechnology component of the] Research and Information System for the Non-Aligned and Other Developing Countries (RIS); and
5. The international scientific community through the International Union of Microbiological Societies (IUMS), the International organization of Biotechnology and Bioengineering (IOBB), the World Federation for Culture Collections (WFCC), African Association for Biological Nitrogen Fixation (AABNF), and the International Cell Research Organisation (ICRO) Panel on Applied Microbiology and Biotechnology.

The success of the MIRCEN activities is due to a reliance on a minimum of bureaucratic and hierarchical frameworks. Collegiality and close collaboration have helped counteract the impact of hard-to obtain resources in these troubled times. Following in-house and external evaluations, emphasis has been given more to program implementation rather than to the strengthening of administrative infrastructure. Complementary backstopping provided by national institutions and universities hosting MIRCEN facilities reveal a commitment and a concrete partnership that helps secure regional and international cooperation in harnessing the biotechnological labor force for economic progress. Indeed, the “writing of computer programs and the revealing of genetic codes have replaced the search for gold, the conquest of land and the command of machinery as the path to economic power.”

Over a 25-year period, and amongst the constellation of partnerships, professional non-governmental organizations and stakeholders in biotechnology, the cooperation between UNESCO and the ASM stands out in having enriched and strengthened the then UNESCO microbiology and now MIRCEN biotechnology programs. This has been done through provision of resources, financial and in-kind, for action-oriented and cost-sharing activities such as the UNESCO/ASM Travel Awards and UNESCO/ASM Visiting Resource Persons Programme.

Since the mid-80s, the ASM, as a guarantor with the National Academy of Sciences, has secured U.S. governmental funding for the UNESCO MIRCEN programs and individual MIRCEN activities. As some of you may know, the International Committee of the ASM administers the NAS/ASM grant for MIRCEN activities.

Also the establishment of the Dakar MIRCEN is a direct result of a pilot fact-finding UNESCO/NAS/ORSTOM mission at the start of the 1980s in which the Beltsville MIRCEN participated. Such catalytic and well-appreciated support has been documented in UNESCO reports, ASM News, and elsewhere.

The MIRCEN research and training programs, especially in the developing countries and those in transition to development in Central and Eastern Europe, have thus benefited from ASM reference texts for updating of curricula and research programs and for the institution of benchmark standards of academic excellence in international cooperation. It is worthwhile noting that UNESCO's approved program and budget for 2002-2003 makes specific mention of the ASM as a technical partner and guarantees the continued monitoring and securing of the scientific quality of the global MIRCEN network activities in the immediate years ahead.

For the future, it is our common hope that the several high-quality national, regional, and international MIRCEN activities will continue to contribute to capacity building in the emerging priorities in the biotechnologies. Lessons learnt, within the framework of regional and international perspectives and viewpoints, indicate that there is a need for capacity building and of disseminating the use of good practices concerning the scientific, legal, and ethical aspects relating to the use of the biotechnologies. Thus, it seems that there is a challenge and need for devising educational and capacity building schemes that enable developing countries to embark, possibly in network cluster groups, or in twinning arrangements with the industrialized countries, on the path of economic and sustainable development, once account has been taken of their level of research in biotechnology; of their capacities to produce and to commercialize biotech products; of their degree of participation in developing national, regional, and international biotech governance dealing with biosafety, conservation, and trade of genetic diversity; and of their ability to engage in national education and regional training since the scope and scale of technical literacy in biotechnology varies amongst countries in a region.

Today, in welcoming the MIRCEN directors, it is a pleasure to welcome, also, new colleagues who have taken over the torch and responsibility of international cooperation from their predecessors in furthering the conduction and expansion of their own national and regional MIRCEN activities. I wish them well and all success in their future efforts, and hope to read of their achievements in the technical and public press.

Also having the floor, permit me please to make a few personal remarks. The evolution of the MIRCEN network is the result of your combined and individual efforts, which I have witnessed, first hand, for over a quarter of a century. Each of you, and I do wish that I could name every one of you, have made an inestimable contribution. I do acknowledge and pay tribute to your priceless and tireless efforts. I am indeed fortunate to share in this experiment of invaluable international cooperation and do thank you for giving me the opportunity to do so, and to work with you.

2. Biological Nitrogen Fixation [BNF] MIRCENs

2.1. Rhzobium MIRCEN Porto Allegre in Brazil

2.1.1. Introduction

The Porto Alegre MIRCEN was established within the framework of the UNEP/UNESCO/ICRO Project "Development of an integrated program in the use and preservation of microbial strains for the deployment in environment management."

Twenty-four years ago, in 1978, the Brazilian Government signed an agreement with UNESCO for the establishment of the MIRCEN in Porto Alegre, Brazil, integrating the efforts of two institutions: the Foundation of Agricultural Research (FEPAGRO) of the Secretary of Science and Technology of the state of Rio Grande do Sul (former State Secretary of Agriculture), and the Federal University of Rio Grande do Sul (UFRGS).

Since that time, the Porto Alegre MIRCEN remains faithful to the MIRCEN concept, designed at the 1970 meeting of the United Nations Environment Programme in Nairobi, Kenya, aiming to disseminate the use of applied microbiology in developing countries.

2.1.2. Activities of MIRCEN Porto Alegre

The MIRCEN Porto Alegre has been active in teaching rhizobia/legume technology and biodegradation/biodeterioration. During the last 24 years of activities, 696 microbiologists and agronomists, from 20 countries in Latin America, the Caribbean, Zambia, Cape Verde, and Moldova, have been trained in short courses and practical training internships at Porto Alegre MIRCEN. The three main types of training and research are:

1. Masters level training in Agricultural and Environmental Microbiology UFRGS. From 1989 through today, the course has trained 98 microbiologists in the following areas: soil microbiology, biofilms, corrosion, food microbiology, biological control, plant pathology, molecular biology, and fermentation processes. In 2003, the course should be offering a Ph.D. degree in the above areas of research.

2. Rhizobia/Legume Technology. From 1979 until 2001, 12 short courses were organized on Rhizobia/Legume Symbiosis, with the participation of more than 200 students, from 20 countries in South and Central America, the Caribbean, and two African countries During intern practical training (2-20 weeks), 70 microbiologists and technicians worked in the UFRGS/FEPAGRO laboratories, mainly on inoculant quality control, inoculant production, and rhizobia strain selection.

Most of these short courses and intern practical training courses were made possible by the support received from UNESCO, UNEP, the Brazilian Research Council (CNP), and the State Research Foundation (FAPERGS) for the travel and maintenance of the instructors and students.

3. Training in Biodeterioration and Biodegradation. Since 1991, the MIRCEN has promoted several courses and internal training on biodegradation and biodeterioration. Besides Brazil, the courses have been taught in other countries, such as Argentina, Uruguay, and Venezuela. Of the courses held in Brazil, 434 microbiologists and technicians have been trained. Other training courses have been given in the MIRCEN Laboratory on biodegradation, biodeterioration, food microbiology, microbiology of air, and biodeterioration of buildings .

4. Maintenance of Culture Collection of Rhizobia. Another important activity is the preservation of rhizobia genetic resources. The culture collection of the Foundation of

Agricultural Research (FEPAGRO) of the Secretary of Science and Technology, of the state of Rio Grande do Sul, is the official culture collection maintaining the major *Rhizobia* cultures of Brazil. The selected cultures are distributed to research institutions throughout the world, and to inoculant industries of the country.

Over 1,200 *Rhizobium* and *Bradyrhizobium* strains are now kept in the culture collection. All rhizobial cultures known to be efficient inoculants have been freeze-dried, and we are now in the process of freezedrying the remainder. The collection consists both of strains native to Brazil and strains imported from other countries.

A computerized catalogue was produced in 1992 and the 8th edition, which lists all the strains, is now available. A catalogue listing all the efficient strains held in Latin American laboratories is also available.

As the result of work done at the MIRCEN, and at other Brazilian and foreign laboratories, cultures of efficient strains are available to inoculant producers and research institutes worldwide.

5. Dissemination of Rhizobial Cultures The culture supply demand for other laboratories, and to the inoculant industries, has increased markedly since the establishment of the Porto Alegre MIRCEN. In 1978 only 43 cultures were sent out, while 620 were supplied in 1989. In 2001, the cumulative total number of cultures dispatched since 1978 reached 7,343, distributed among 15 countries in Latin America and 23 countries in other parts of the world

During the past year, 373 cultures were sent to other research institutions and 174 were sent to inoculant manufacturers. Freeze-drying of existing cultures continued, with 40 strains being processed—a total of 481 ampoules.

In order to check the maintenance of the potential for nitrogen fixation of the recommended strains, 15 greenhouse experiments were carried out in 2001.

6. Production and Quality Control of Inoculants

Small-scale production of inoculants for small farmers, experimental stations, and extension agencies is an important activity for the dissemination of the practice of legume inoculation. In 2001, there was a significant increase in the demand for tropical and temperate legume crops besides grain legumes, as listed: *Vigna sinensis, Lab-lab purpureus, Crotalaria* sp., *Stylozobium* sp. *Cajanus cajan, Glycine whightii, Leucaena leucocephala, Desmodiun intortum, Medicago sativa, Glycine max, Phaseolus vulgaris, Vicia sativa, Pisum arvense, Trifolium vesiculosum, T. pratense, T. subterraneum, T. repens, Lupinus* sp., *Lotus corniculatus, Pisum sativum, Lens esculenta, Cicer aretinum*. In total, 1,700 packages of inoculants were produced.

The MIRCEN/FEPAGRO runs the official quality control of inoculants produced by the manufacturers as determined by the federal Ministry of Agriculture, as well as informal control upon request from farmers and manufacturers.

7. International Cooperation

The Porto Alegre MIRCEN also maintains international cooperation with the Laboratory of Microbiology of the Universidad Nacional de La Pampa, Argentina (A.P. Balatti); the Laboratory of Soil Microbiology of Ministerio de Agricultura of Uruguay (C. Labandera); Laboratory of Environmental Microbiology; Pontificia Universidad Javeriana, Bogotá, Colombia (M. M. Martinez); Universidad de La Plata, Argentina (H. Videla); INTEVEP, Venezuela; Universidad de Campeche, México; Instituto Superior Técnico, Portugal; and the Universidad de Madrid, España.

Director: Jardim Freire, FEPAGRO, Faculdade de Agronomia – UFRGS, Caixa Postal 776, Porto Alegre R.S., Brazil,

2.2. Rhizobium MIRCEN Nairobi in Kenya [see also *Biological Nitrogen Fixation*]

2.2.1. Introduction

In sub-Saharan Africa, per capita food production of food grains from 1960 to the early 2000s has stagnated and finally declined. Evidence for this food insecurity is clearly manifested in food imports and food relief operations directed to African countries south of the Sahara.

Several factors leading to these frequent food shortages include:

1. The poverty constraint, which significantly limits the ability of the small-hold farmer to purchase fertilizers and other agricultural inputs needed to raise and sustain the levels of high crop productivity
2. The rising population, which diminishes agricultural land sizes
3. Continuous cultivation of land, with negligible or no nutrient returns, and the economic policies regarding agricultural inputs that do not favor the purchases of such inputs The importance of BNF to world food security is unquestionable. Most tropical soils are fragile in structure, are of low soil fertility, and inappropriate farming technologies can result in low yields. Even though small-holder cropping systems in eastern and southern Africa are mainly maize based, the cultivation of legumes is also widespread and their exploitation is designed to meet a wide range of needs. These needs include: human nutrition, livestock feed, fuelwood, structural materials, prevention of soil erosion, and fertility management.

The need for nutrient replenishment within the small-hold farming system is crucial in the eastern and southern African countries, in order to meet human nutritional requirements, now and in the future. In this context, BNF is crucial since nitrogen is a major nutrient that limits plant growth in tropical soils [see also *Biological Nitrogen Fixation MIRCEN*]. However, maximization of the benefits accrued from legumes is limited by a widespread deficiency of phosphorus in croplands, which are mostly associated with low pH coupled with high aluminum and manganese toxicities. The presence of high populations of indigenous *Bradyrhizobium* sps. in tropical soils that nodulate with commonly grown legumes has also acted negatively on the response of cultivated plants to rhizobia inoculation.

2.2.2. Legume Niches in Farming Systems

Small-hold cropping systems in eastern and southern Africa are maize based, but then the cultivation of legumes is widespread and their exploitation is designed to meet a wide range of needs as referenced above. The niches elaborate on the various roles legumes play in small-hold systems and may be regarded as a reference to assess the effectiveness with which legumes are exploited on farms within the region. The various niches are presented diagrammatically in Figure 1.

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Biographical Sketches

Horst W.Doelle, born in 1932, studied biology at the University of Jena [1950-1954]. He studied for his doctorate at University of Goettingen [1955-1957] on antibiotic production. After receiving his doctorate, he worked in the Wine and brewing industry in Germany before taking up an appointment with CSIRO in Australia in 1960. After 4 years wine research, he took up the challenge to build up microbial physiology and fermentation technology at the Department of Microbiology at the University of Queensland in Brisbane. He received his Doctor of Science in 1976 and his Doctor of Science *honoris causa* in 1998. He participated and conducted numerous training courses in developing countries. After 29 years teaching he retired in 1992. His research area was regulation of anaerobic/aerobic metabolism, microbial technology [*Zymomonas* ethanol technology] and socio-economic biotechnology using microorganisms for waste management.

Faustino A. Siñeriz graduated at the University of Buenos Aires in 1965 and received his Ph.D. in 1973 at the same University. From 1974 to 1977 he did post-doctoral studies at Queen Elizabeth College, University of London, with John Pirt and at the New York State Health Department in Albany. He was an Alexander von Humboldt fellow at the University of Konstanz, Germany, in 1984-1985. He held several positions at the University of Buenos Aires, University of Cordoba and University of Tucumán, where he is now of Microbiology. In 1978 he entered the Research career in CONICET and since 1986 is Director of PROIMI, a research institute from CONICET specializing in fermentations and microbial biotechnology. His research interests include microbial physiology applied to biotechnological processes, continuous culture, bioremediation and wastewater treatment. He has participated as author or coauthor in more than 80 scientific publications in international journals. He is a fellow of the American Academy of Microbiology since 1998.