THE ROLE OF MICROBIAL RESOURCES CENTERS AND UNESCO IN THE DEVELOPMENT OF BIOTECHNOLOGY

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[*This chapter is dedicated to the memory of the late Edgar J. DaSilva, who was the Director of the Life Science Division in UN and contains excerpts from contributions given by him after his retirement together with cancelled presentations to the Nobel Symposium of the World Academy of Art and Science in 2000*]

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Contents

Summary

The design, growth and expansion of the UNESCO MIRCEN is the result of international co-operation that has been sustained by the involvement of governments; UNESCO National Commissions; UN agencies and programs (FAO, WHO, UNIDO, UNU, UNDP and UNEP); governmental bodies (OAS, CSC), the international scientific community through the ICRO Panel on Applied Microbiology, IUMS, IOBB, WFCC, SCOPE, AABNF, the MIRCEN network of institutions, and numerous individual MIRCEN researchers in the developed and developing countries.

The nominated person to start and expand this proposed Microbial Resource Centre Network was **Edgar J. DaSilva**, the Director of the Life Science Division in UNESCO in Paris. It was due to his zeal, his complete dedication to the task, and his personal charm, that the network developed and produced new developments. At the beginning, eight centers, Australia, Egypt, Guatemala, Kenya, Senegal, Sweden and Thailand were identified and established within the framework of the now completed UNESCO/UNEP project. Under the magnificent leadership of Edgar DaSilva, the MIRCENs have expanded from 8 to a network of 34 Microbial Resource Centres.

1. Preliminary History

Biotechnology is a technology using biological systems and parts thereof. Since the basic unit of any biological system is the cell, any biotechnological approach will and does involve living and/or resting cells or their enzymes of many kinds, such as bacteria (prokaryotes), yeast, fungi, plants and animals (eukaryotes) including man. Depending on the specific purposes and needs, wild-type cells, natural mutants or genetically modified cells are employed. In most cases, the cells are not grown under natural conditions but are cultivated under more or less strict control in semi-artificial or artificial environments.

Biotechnology has its roots in fermentation, a process requiring a *ferment* to convert complex molecules into different chemical compounds [see *Biotechnology*]. Fermentation itself has been practiced for many centuries. Bread, cheese, pickled cabbage together with beer, mead and wine making are believed to have occurred under Egyptians, Romans, Greeks and Germans around 5000 BC. Algae of the genus *Spirulina* were harvested for food from alkaline ponds by the Aztecs in Mexico. The origins of a variety of indigenous 'fermented' foods and sauces in Africa and Asia using surface culture methods go back thousands of years.

As soon as it was realized that not only microorganisms, but also plants and mammalian cells could be cultivated and used as organic catalysts in product formation, and that cells of either source could be manipulated by transferring genes from one to the other, that the term Industrial Microbiology had to be widened and became, around 1980, Biotechnology.

It is of interest to realize that the word 'biotechnology' itself has gone through an evolutionary development since it first was introduced in 1919 by the Hungarian agricultural economist Karl Ereky. He coined his new word to cover the interaction of biology with technology. The first use of the word in the English language appeared in the journal *Nature* in 1933. The most important definition of biotechnology, however, was published in 1938, when Julian Huxley stated that "biotechnology will in the long run be more important than mechanical and chemical engineering". In 1962, the '*Journal of Microbiological Technology and Engineering*' changed its name to '*Biotechnology and Bioengineering*', whereby its editor, Elmer Gaden, used the word biotechnology representing 'all aspects of the exploitation and control of biological systems'. It was only in the late 1970s and early 1980s that the word became more associated with genetic engineering [see also *Fundamentals in Biotechnology*].

The basic and fundamental unit of biological systems is the individual cell. Whereas microorganisms like bacteria and yeast are predominantly unicellular, septated fungi, plants and animals are predominantly multicellular. In order to be able to use these cells for biotechnological applications, it is important:

- to find the cell and keep the cell alive, in other words to cultivate the cell;
- to determine the optimal nutritional requirements for growth;
- to determine the optimal and most economical requirements for product formation;
- to find preservation techniques; and
- to be able to modify the genetic structure of the cell to achieve the required product formation with enhanced yields.

All five aspects not only require a thorough knowledge in growing and cultivating the cell, but also in its thermodynamics and especially their biochemistry [see also *Cell Thermodynamics and Energy Metabolism*].

In sharp contrast to the usual requirements for academic research, organism isolation and initial selection for an industrial process is dependent on a range of criteria that are relevant to the optimization of the particular process. Their features may be morphological, physiological, genetic, immunological, and the sum of all these features of a microorganism is referred to as its phenotype. A phenotype therefore represents any visible and/or measurable characteristic or distinctive trait possessed by an organism. In contrast, the genotype represents all genes possessed by a cell or organism. This genotype can therefore be explored via phenotypic expression.

The new and fast developing area of gene technology, which has its basis in the improvements of recombinant DNA technologies, allows us to expand the phenotypic expression of a cell through rearrangements of its genotype. [See *Biotechnology*]

2. UNESCO and GIAM

UNESCO, at the crossroads of education, science, culture and communication, and the social sciences is a unique institutional setting for dealing with human and sustainable development. Throughout its life-span of the last fifty years and more, UNESCO has been in the forefront as a sanctuary of time-honored values - human, moral, traditional, etc., in a world of continuous change. As in other fields of international endeavor and co-operation, much is owed to many men and women of academic, cultural, intellectual, and philosophical distinction, coming with their precious contributions from all corners of the world weaving together with the threads of moral values, national cultures, customs, and, solidarity in collegiality and comradeship, the skeins of international co-operation for the advancement and betterment of human life in a world of continuous change.

In the field of microbiology, since the mid-1950s and then later in the domain of the biotechnologies, the name of Carl-Göran Hedén is intricately associated on account of his foresight into the then futuristic developments which today are reality. Carl's ability to gather around him colleagues and friends committed and devoted to the cause of applying the incomparable molecular power and enzymatic machinery of the invisible microbe for provision of a variety of goods and materials for human sustenance and development, is legendary.

Hedén foresaw already in the 1970s the issue of ethics which today is an integral component in the application of the biotechnologies for human welfare. Through a conference on *Science, Culture et Santé du Monde* Hedén visualized the need for an ethical management of health on the path traveled from the oath of Hippocrates to the modern-day social contract that serves as the guarantor of human health in today's world of bio-commerce. As he then indicated "this constitutes a challenge for everybody concerned with patient's rights movements and with the education of the "*consumers*" of the avalanche of new products that are derived from molecular biology and biotechnology". An echo of that foresight is today being encountered in the debate concerning genetically-modified foods and organisms, and bioethics in general.

Concern that human fertility will outstrip human ability to produce enough food to feed humankind has always been in the forefront since the days of Thomas Malthus. The specter of mass starvation, the decrease of foodstocks coupled with loss of human dignity; and the menaces of food insufficiency and insecurity, have at one time or another been evoked. Since the 1960s, human ingenuity has attempted to design and provide solutions through the use of the green and gene revolutions which complement the metabolic machinery of the invisible microbe that has long been used to remedy soil fertility and increase crop yield.

The UNESCO Program in applied microbiology with its implications for long-term sustainable development traces its origins back to 1946 (Fig.1) when UNESCO supported research that was geared to the conservation and applied use of microorganisms.

Since that time, UNESCO activity in the discipline has been done in co-operation with the International Cell Research Organization (ICRO), with the International Organization for Biotechnology and Bioengineering (IOBB) and the World Federation for Culture Collections (WFCC), all of which were founded with UNESCO support and encouragement. In brief, it is a program that has been enriched and nurtured, since birth, by individuals, governments and non-governmental organizations (Fig.2).

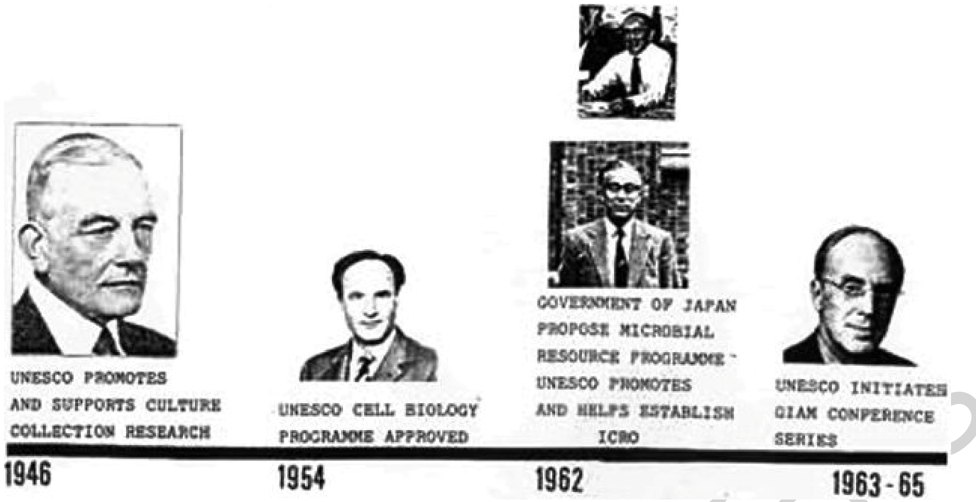

Figure.1. 1946: A. Kluyver (Netherlands);1954:A. Kepes (France);1962: G. Terui (top) and K. Arima (Japan); and C.G.Hedén,1963: UNESCO initiates GIAM conferences

Figure 2: *First Row:* V.B.D.Skerman, *Second row*: (top to bottom):H.Gyllenberg (Finland); C.G.Heden (Sweden), I.Malek(Czechoslovakia)/ T.Hasegawa (Japan), S.Martin (Canada), and S.Lapage (U.K.)

Taking into account recommendations in resolutions adopted at the *VIII International*

Congress for Microbiology in 1962 in Montreal, the *U.N. Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas* in 1963 in Geneva and the *First Global Impacts of Applied Microbiology Conference* (GIAM-I) in 1963 in Stockholm, the Government of Japan submitted a resolution to the 12th session of General Conference of UNESCO to initiate a program promoting research in microorganisms. Acceptance of the resolution in 1963 by the Member States of UNESCO constituted recognition of the necessity to domesticate the then neglected resource of microorganisms, to the same extent, as those of the plants and the animals for the benefit of all countries.

The series of the *Global Impacts of Applied Microbiology Conference* (GIAMs) was designed, by its founding fathers i.e. Carl-Göran Hedén (Sweden), Kei Arima (Japan), Jacques Senez (France), Maurits LaRiviere (Netherlands), Martin Alexander (USA) and Anton Burgers (UNESCO), to mention a few, as a mechanism for focusing the attention of fellow scientists, decision-makers and science policy framers on the potential applications of microbiology that could be used towards providing some solutions to the important areas of health, food and the environment that are of vital significance to problems in especially the developing countries. Furthermore, the GIAMS were to raise the windows of the research programs of fellow microbiologists in the developed world to problems that are more germane to the needs and the priorities of the developing countries. Enthusiasm, scientific goodwill and technical contributions from the industrialized societies to the GIAMs have been eloquent testimony of a motivated concern and deep scientific and social comradeship aimed at fellow microbiologists in the developing countries. This testimony has taken the form of spin-off research fellowships and grants focusing on overall socio-economic development, and implementation of applied microbiological research in the fields of food, biofertilizers and bioinsecticides production that could help the technological advancement of the developing countries. Through the span of 30 years, the GIAMs have benefited from valuable support and inputs from a number of U.N. bodies, national bodies, non-governmental organizations and commercial enterprises

*GIAM I - 1963 (Stockholm, Sweden)	Organized with the Economic and Applied icrobiology Section of the International Association of Microbiological Societies (IAMS); Royal Swedish Academy of Engineering Sciences of the Government of Sweden; & WHO.
GIAM II - 1967 (Addis Ababa, Ethiopia)	Organized with the Government of Ethiopia and the UNESCO/ICRO Panel on Microbiology; and WHO.
GIAM III - 1969 (Bombay, India)	Organized with the University Grants Commission, Atomic Energy Commission, Indian Council of Agricultural Research & Indian Council of Medical Research - Government of India; the UNESCO/ICRO Panel on Microbiology; WHO & with support from Vatican, Smithsonian Institute, Esso-Nestle.
GIAM IV - 1972 (Sao Paulo, Brazil)	Organized with the Ministry of Education and Culture - Government of Brazil ,the UNESCO/ICRO Panel on Microbiology; and WHO.
**GIAM V - 1977 (Bangkok, Thailand)	Organized with the Government of Thailand, the UNEP/UNESCO/ICRO Panel on Microbiology; UNEP,& IFS.

GIAM VI - 1980 (Lagos, Nigeria)	Organized with the Government of Nigeria, the UNEP/UNESCO/ICRO Panel on Microbiology; UNEP; and the Commonwealth Fund.
GIAM VII - 1985 (Helsinki, Finland)	Organized with the Ministry of Education - Government of Finland, & ICRO Panel on Applied Microbiology and Biotechnology.
GIAM VIII - 1988 (Shatin, Hong Kong)	Organized with UNEP, Committee on Science & Technology in Developing Countries (COSTED); International Union of Microbiological Societies (IUMS); Hong Kong Society of Microbiology (HKSM), Hong Kong Research Council in Biological Education (HKRCBE); and Commonwealth Fund.
***GIAM IX - 1990 (Valetta, Malta)	Organized with UNDP and Government of Malta
GIAM X - 1995 (Copenhagen, Denmark)	Organized with Danish National Commission for UNESCO and ICRO Panel on Applied Microbiology and Biotechnology

* UNESCO/WHO Co-operation in GIAMs I - IV
** UNESCO/UNEP Co-operation in GIAMS V and VI within the framework of the UNESCO/UNEP/ICRO. Project on “Development of an Integrated programme in the Preservation and Conservation of Microorganisms for Deployment in Environmental Management” (starting July, 1975 and successfully concluded October, 1984)
*** UNDP/UNESCO project: Microbial Biotechnology and Bioengineering (Biotechnological Applications) - European Network (1988 -1993)

Table 1. A Summary of Global Impacts of Applied Microbiology Conference (GIAM)

GIAM	**Year**	**Place**	**Remark**
GIAM I	1963	Sweden	Opens window & expands vision in developed countries to applications of microbiology for socio-economic advancement in developing countries
GIAM II	1967	Ethiopia	Contributes to emergence of microbiology in Africa with focus on: • bioconversion technologies, *Spirulina* • 5-year collaborative programme between Haile Selassie I University (*Ethiopia*) and Hadassah Medical School (*Israel*)

GIAM III	1969	India	• Establishment of University Departments in Bombay and Goa
			• Institution of national postgraduate fellowship in microbiology
			• Initiation of collaborative research on:
			  o arboviruses between India and Sri Lanka
			  o use of blue-green algae in rice cultivation between Arab Republic of Egypt and India

GIAM IV		Brazil	• Stimulates need to conserve microbial genetic resources for regional development • Blue-prints for *Future of Microbiology in Developing Countries*, and of *Teaching and Training in Microbiology* set stage for UNESCO/UNEP co-operation
GIAM V	1977	Thailand	• Emergence of Southeast Asian Network in microbiology with support from Government of Japan • Focus on Indigenous Fermented Foods • University-Industry co-operation

			• Collaboration with UNU
GIAM VI	1980	Nigeria	• Emergence of African Network for Microbiology • Kick-start of initiatives with UNDP in medicinal plants, and use of BNF technology in agriculture
GIAM VII	1985	Finland	• Focus on *Partnership for Progress* • Recognition of evaluated MIRCEN network as viable mechanism for inter-regional co-operation • Growth of MIRCEN Journal
GIAM VIII	1988	Hong Kong	Window on interaction of two cultures in applications of microbiology for national development; Commemoration of 25th anniversaries of Chinese University of Hong Kong and GIAMS
GIAM IX	1990	Malta	• Focus on co-operation in Europe with emphasis on biotechnological applications in Central and Eastern European countries • Emergence of *BITES* electronic exchange system with UNDP/UNESCO support
GIAM X	1995	Denmark	• Window on emergence of reverse transfer of technology • Increase in geographical contributions to *World Journal of Microbiology and Biotechnology* - Official Journal of the MIRCEN network

Table 2. GIAMS Spinoffs

In essence, the GIAMs were aimed at appraising and confronting high governmental officials, administrators, research workers and students with the latest developments that had profound scientific, economical and social application. Problem-oriented towards the developing countries, broad in scope and vision, and deep in technical content, the GIAMs provided returns (Table 2) that bear testimony to the interest and joint co-sponsorship of UNESCO and WHO in the years 1963 - 1972, and to that of UNESCO and UNEP in the years 1977 - 1990 and which knowledge-wise warrant implementation of in-depth reflections

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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 Prof. 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