Biological Education: Challenges of the 21st Century

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Introduction

Generally speaking, education represents the domain through which humankind proceeds to transmit, consolidate and develop into human culture, the ensemble of knowledge systems, science, arts, values and religions.

In a report entitled "Learning - the Treasure Within," presented in 1996 to UNESCO, Jacques Delors, former President of the European Commission, and his colleagues recommended that education must be given top priority on the agenda of nations. Priority to the role of education in providing citizens with a 'passport to life' with which they learn to be, learn to know, learn to do and learn to live together. Educational activities now represent a major occupation of human societies. In-school education is a full-time occupation of a large part of the world's population (more than one billion students and 20 million teachers, in 1992), and occupies, on average, one quarter of every individual's life. Increasingly some form of out-of-school education is pursued throughout life. From an economic point of view, the world expenditure on formal education in 1996 totaled approximately 1,200 Billion US$ (an average 5,1% of the world GNP). This budget represents the largest investment in the national accounts of many countries, yet it is still considered insufficient to cover actual needs.

During the 1990's, with their eyes fixed on the approaching year 2000, a large number of governments, national and international organizations and groups engaged in a trendy exercise. They participated at large scale conferences with the express aim to assess past achievements and failures, reap the lessons gained throughout the 20th century and identify the key challenges facing humankind at the beginning of the new Millennium. The first such event was the Earth Summit on Environment and Development held in 1992 in Rio-de-Janeiro, followed by the World Population Conference in 1994 in Cairo, the World Conference on Higher Education in 1998 in Paris, and the World Conference on Science in 1999, in Budapest, Hungary.

From these fora, there emerged a world consensus on the role of education, science and technology as the prime movers and most decisive factors of development. International programs and plans of action were launched: the Agenda 21, Education 2000+, Taxonomic Agenda 2000, Species 2000, and the Programs 'International Geosphere and Biosphere Program (IGBP), and the International Human Dimension of Global Change (IHDP), etc.

The recent history of human societies shows how scientific and technological progress have helped trigger economic, social and cultural development. In the 19th century, advances in physics, chemistry and engineering conduced to the industrial revolution. And in the 20th century, advances in agricultural sciences, physiology, genetics and breeding of plants and animals provided the basis for the agricultural (green) revolution; new knowledge in microbiology, immunology, medical and pharmacological sciences helped reduce the toll of diseases, and resulted in an increased life expectancy.

The discovery of the DNA structure and function ignited a biological revolution which will continue and expand during the 21st century. Deciphering the genetic code (alphabet) represents an essential step in the human endeavor to read the book of life, unravel the complexity of biological systems (molecules, cells, organisms and ecosystems), and perceive the unity of life through the diversity of living forms. Progress in the biological sciences is not only bringing about an understanding of the evolutionary processes and pathways which led to the present world, but also giving the humankind the power to modify drastically the course of biological evolution, including his own.

Like other scientific disciplines, biological sciences form a part of the overall human culture, which represents a specific evolutionary trait of *Homo sapiens* and marks the border line with other primate species. However, whereas biological traits are transmitted between generations through reproduction and modified through mutation processes, cultural traits (values and knowledge) are inherited and modified (scientific and technical innovations) through education, i.e., the ensemble of learning, training and research processes.

In all these processes, biological education, education about life, education through life and education for life, occupies the center stage.

New biological knowledge

During the second half of the 20th Century, impressive achievements and breakthroughs have been made in the fundamental and applied knowledge of the living world , with far reaching implications impacting almost every aspect of human life and society.

At the micro-level, the development and use of sophisticated molecular biology techniques have lead to a revolution and the emergence of new disciplines, such as Molecular Biology, Molecular Genetics, Molecular Evolution and Genomics. Tremendous progress and breakthroughs have been achieved in our understanding of animal and plant reproduction and development, and more generally, our understanding of evolutionary processes. At the macro-level, the development of new concepts, new approaches and techniques, and the use of modeling, remote sensing and informatics are bringing about a revolution in the ecological sciences and the emergence of sub-ecological disciplines such as Functional Ecology, Landscape Ecology, Global (Biosphere) Ecology and Ecological Networks.

The biological sciences have seen the emergence of important interdisciplinary scientific domains, such as biodiversity, bio-complexity and integrative biology.

New Problematique

A new perception and formulation of the world problematique emerged at the Earth-Summit of 1992, in Rio-de-Janeiro, Brazil, replacing the traditional and fragmented vision of the problems facing human societies (individually and collectively). There is now a better understanding of the relationships and interconnections between the problems affecting human health, food and environment, problems related to agriculture and agro-industry, fisheries and aquaculture, pharmaceutical industry and biotechnologies, the problems of pollution (physical, chemical and biological), as well as problems related to the conservation and management of biological resources (deforestation, desertification, soil salinization and loss of biodiversity, etc.)

The new problematique that emerged at the Rio Summit is based upon a trilogy consisting of biodiversity, global change and sustainable development.

The awareness of biodiversity at the three levels of biological organization: the genetic, organismic and ecological levels (di Castri & Younès, 1996), highlighted the need to better understand such issues as the origins, maintenance and change of biodiversity over space and time scales, the ecosystem function of biodiversity and the many hidden ecological services it provides to humankind, the need to better conserve and manage the biodiversity of terrestrial, marine and inland-water systems, providing clues of how to restore degraded ecosystems. There is also a growing perception for the need to take into consideration the human dimension of biodiversity and, in particular, cultural diversity.

The second important issue, the global change and globalization phenomena, has been considered at the environmental, economic, and information/communication levels. Pollution problems do not recognize political boundaries between states, and global warming and ozone holes affect the whole biosphere. To face these problems, it is necessary to form a global coalition, with all nations working hand-in-hand, if we are to succeed.

The third and last “mot d'ordre” of the trilogy consists in sustainable development. This new concept, developed during the Earth Summit, aims at promoting a much needed solidarity over both space and time scales. On the geographical scale, this means a solidarity between North and South, between developed and well-off nations and the developing poor countries of the third world. And, over a time scale, it implies a solidarity with the future generations, taking into consideration the well-being of the generations to come, and leaving their options open.

Facing these challenges, research, training and education in science, particularly biology, are pre-requisites if we are to succeed in bringing about an economically efficient, socially equitable and environmentally sustainable development.

New Educational Concepts and Approaches

The goals, scope and content of biological education vary greatly with its target populations and the groups and parties involved in its implementation. Biological education means different things to different people. For biology researchers, education means the acquisition of the scientific knowledge, data and techniques that are necessary to perform research projects. For developers, professionals and engineers in a large variety of domains such as agriculture, health, industry, biotechnology and environment, education must provide the biological foundations underlying their respective domains of expertise. And for the general public, the principal aim of biological education, whether at schools (primary and secondary) or through the media, must be to develop citizens' biological literacy, i.e., provide them with the core biological knowledge, the ability to formulate questions, and an idea of how and where to look for answers, in order to help them to participate responsibly in the life of the society.

The diversity of the objectives assigned to biological education reflects its social function which is to re/produce knowledge, apply it and adapt to its impact on society. Therefore, addressing the challenges of biological education for the next century requires taking into consideration not only the new problematique and new scientific knowledge, but also to address the ethical dimension of biological sciences as well as the new findings of research on education processes and learning theory.

Biology, psychology and cognitive sciences are generating knowledge about how the human brain learns; and have shown us that we can use this knowledge to intervene effectively in the learning process of virtually any and all humans. In a comprehensive study of the theory of learning, Giordan, 1998, explains that learning is better achieved through a process of deconstruction. Concepts have evolved from the old passive process, whereby teachers passed or communicated their knowledge to students considered as empty containers; to the behaviorist and constructivist approach by which the teachers help the learners to construct knowledge, moving from the simple to the complex and from the specific to the general; and finally the development of a more active approach, whereby the re-construction of knowledge follows a necessary phase of deconstruction, i.e. a process by which the knowledge is generated (appropriated) by the learners themselves.

The adoption of this new learning concept has important consequences for the organization and functioning of educational institutions and curricula, the definition and practice of the respective roles of teachers versus learners, and the relationship between knowledge acquisition and learners' attitudes, behavior and ability to adapt to complex and ever-changing environments.

The development of the deconstructivist concept and the reconstructivist approach have led to more educational institutions adopting a new method of "learning science as scientists do." Students are invited to participate in research projects designed for them and the results of which are presented at major scientific congresses and published. At the AAAS Congress in 1999, held in Anaheim, USA, there were two major poster sessions

with hundreds of 'young' scientists (students at secondary schools) presenting their research results!

Another important consequence of adopting the re-constructivist approach consists in its great potential to reinforce the societal relevance of biological education, i.e., the link between science education and the needs of society, which, in turn, calls for the development of ethical dimensions of science education.

New Tools for Education

Today, the statement "*If only biologists knew what biology knows*" is more true than ever. The explosion of scientific knowledge and the rapid production and accumulation of staggering amounts of scientific data and information are creating the need for knowledge management, i.e., knowledge about knowledge. Actually, knowledge management is about learning. It is impossible for educational systems to cover all domains of knowledge, there is a need for school science curricula to provide citizens with basic scientific literacy, i.e., a common core of understanding, a knowledge basis and the intellectual ability to formulate questions and find answers.

At the same time, the explosion of scientific and technological knowledge is introducing new concepts and tools for distance learning, new access to the world storehouse of knowledge, and new interpersonal and group communication capabilities. Two subsequent approaches will also be needed: (1) to develop mechanisms for "learning on demand" within (2) a framework for continuous, life-long education. The success of such an endeavor will mark the passage to the education society, to a knowledge society. Biological training and education will be more and more about knowledge management than the simple traditional teaching of scientific data. Increasingly, modern Information and Communication Technology (ICT) is being developed and used for education in-school and out-of-school situations. In the developed countries, more and more ICT educational material, CD-ROMs and/or online education tools are becoming more available for learners. Modeling and simulation games are being developed. Benefits of introducing ICT are numerous, to mention but a few: increasing interactivity, availability of immediate links with almost an infinite world library, encouraging group work, and providing good tools for auto-evaluation.

However the development of ICT in education, and in particular in biological education still is in its infancy. There is here a large domain for development and research towards reconsidering the learners and teachers' functions and role and rethinking the structure of the school, college and university.

New Actors and Partners

Parallel to the explosion of scientific knowledge, the emergence of a new problematique, and the development of new concepts, approaches and tools, there also are a host of new parties with huge stakes and interest in biological education. Among these parties, there are natural partners wishing to strengthen their role in biological education, such as botanical gardens, national parks and nature reserves, and natural history museums, and

science centers. In addition, a large number of organizations, foundations, and agricultural and industrial corporations (pharmaceutical industries and biotechnology) are concerned with and, to a certain extent, involved in the development of biological education programs.

Prospects and Conclusions

Over the next three days of BioEd 2000, a large number of papers will be presented. The principal aim of the current organization into plenary, parallel or workshop sessions is provide the conditions for good presentations and discussions.

We hope that whenever possible, the discussions will focus on the main issues and problems and suggesting and recommending solutions. For BioEd 2000 to be more than a "happening", a one-time event, every body's contribution will be needed to help pave the way towards the future.

The success in meeting the education challenges will depend upon the dedication, commitment and efforts of all partners involved (scientists, teachers, students, politicians, decisions-makers and the public).

I would like to expand the parallel I mentioned earlier between education and biological reproduction. Because of the pain and high cost of having children and caring for them over a long period of time, the reproductive success of our species, *Homo sapiens,* would have been impossible without this extraordinary invention of life, that is love. This is also true for education, which is the key to the survival of human culture and civilization, love is needed for societies to provide for the high cost that education systems require.

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