

The Necessity to direct Trends into Biology Education and Training at the Tertiary Level

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SUMMARY

The initiative of UNESCO / International Union of Biological Sciences (IUBS) with its Commission for Biological Education (CBE), to discuss the challenge of the next century and to invite the European Countries Biologists Association to present its view from a perspective of professional biologists aims at the same focus: *to promote professionalism in the community of biologists and biology teachers.*

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ECBA, representing approximately 200 000 professional biologists working in Europe in liberal professions, in industry, governments, research institutions, secondary schools and universities, is a 25 years old organization, much younger than IUBS, which celebrates in 2000 its foundation 80 years ago.

(1) ECBA's foundation in 1975 reflects the maturation of biology from a basic science to an applied work field

“Biology,” a term originally coined in 1802, 200 years ago, by Gottfried Reinhold TREVIRANUS, Bremen, Germany, advanced from a purely “scientia amabilis” performed as an avocation by medical practitioners and naturalists at former days to a driving force today with the capacity to reshape life on earth.

Biology's diversification into many specialized biological sciences, the upcoming of a number of applied biotechnologies and the still increasing development of professional fields to fulfil services on public demands are altogether a story of success, culminating in the transformation of national chemical companies into international life sciences industries with slogans like "Our Challenge is Life".

Biology, as an academic discipline, has traditionally been a basic science, which investigated the variety of forms of living organisms in university departments of *botany*, *zoology*, *microbiology* and *anthropology* (human biology). These classical pillars within biology have broadened and diversified notably. The introduction of advanced laboratory equipment and of elaborate techniques in cooperation with physicists, chemists and engineers has led to a dynamic development of research on all levels of biological complexity: on the level of molecules (*molecular biology* and *cellular metabolism*), on the level of cells (*cell biology*, *microbiology*), on the level of tissues and organs (*anatomy*, *histology*, *physiology*), on the level of organisms (*morphology*), on the level of populations (*systematics*, *taxonomy*), and on the level of ecosystems and biota, where the interrelation and interaction of organisms among each other and with their surroundings is analysed (*ecology*).

Some biological disciplines such as *genetics* span all levels of complexity.

Within the different levels dynamic research fields have been developed by biologists which are regarded as autonomous: *biophysics*, *biochemistry*, *cytology*, *neurophysiology*, *immunology*, etc. These all have developed from classical biology and such diversification processes are still going on. More than 80 subdisciplines could easily be named.

The original fear that education and training of biologists in such diversified specialized micro-areas of biology will create graduates unable to bridge the gap between low and high complexity levels seems to be unfounded, as long as a core programme in the curriculum ensures the basic concepts of biology: *structure/function*; *regulation*; *growth*; *development* and *evolution*.

The specialization in micro-disciplines has, on the other hand, resulted in a higher level of specialized expertise opening research opportunities across all of the classical pillars of biology: a cell biologist is educated and trained to fully use the instrumentations for the analysis of cells irrespective of their human, plant, animal or microorganismic origin.

Biological 'Know how' has become the thinking and the use of techniques, methodologies, processes and results derived from fundamental biosciences for the application in the field of *health* (medicine, pharmacy, diagnosis, etc.) *animal production* (growth hormones, feed stuffs, vaccines, reproduction, mareculture, etc.), *plant production* (breeding, pest control, resistance induction, etc.), *industrial use* (biocatalysis, bioconversion, biosynthesis, etc.), *environment* (impact assessment, biomass utilization, waste recycling, biodegradation, etc.) and *education* (bioliteracy of the public, skills and attitudes of biologists, bioethics for researchers and applied biologists).

Nowadays professional biologists in Europe play multiple roles in different fields. We recognize a "biodiversity" of employment in Europe.

Approximately 25% of biologists are employed in secondary schools, another 25% in universities and colleges, 10% in research institutions, 15% in central or local governments, 10% in industry, 5% in consultancy companies, 3% in hospitals and approximately 10% in other fields.

In the future, this type of distribution will change towards an increased proportion of biologists in industry and governments. Additionally, there will be an increased requirement for biologists of different specialities: there are already biologists, certified and recognized in defined fields, servicing special demands. The Institute of Biology (IOB, UK), for example, keeps a register of "Chartered Biologists" which specifies more than 30 different fields of expertise, alone responsible for the 'environment': *Agriculture, Algology, Aquatic Biology and Resources, Arid Ecosystems, Coastal Ecology, Conservation (birds), Conservation (habitats), Conservation (invertebrates), Conservation (mammals), Conservation (nature), Conservation (soils), Conservation (vertebrates), Conservation (wildlife), Ecotoxicology, Environmental Education, Environmental Impact Assessment, Environmental Planning and Policy, Estuarine Ecology, Forestry, Hydrology, Industrial Effluents, Industrial Siting, Land Reclamation, Landscape Science, Land Use, Limnology, Nuclear Power, Pest Control, Pollution (Aquatic, Atmospheric, Estuarine, Freshwater, Heavy Metals, Pesticides), Saltmarshes, Tropical Ecology, Turfgrass, Urban Ecology, Waste Disposal, Water Quality and Management, Wildlife Management.*

The spread of the fields of expertise has always been extending many different areas, ecosystems and grades of biological complexity. The emphasis is changing with more biologists moving into non traditional avenues of employment and fewer entering traditionally important sectors like education at all levels and academic research.

The modern biologist is, generally speaking, equipped with a battery of analytical skills which can be deployed in a variety of contexts ranging from aquaculture through forensic science to genetic engineering.

The modern biologist is also skilled in the use of computers for a variety of purposes and will typically be proficient in the preparation of succinct, clear and informative reports.

When training in basic management skills is allied to these qualities a biologist is very well kitted out for an industrial or commercial career both as a practising biologist or taking a route through the management side of the company which employs him.

To ensure professional biologists competence, ECBA, the European Countries Biologists Association, is awarding the title "European Professional Biologist (EurProBiol)"

(2) The ECBA-Title "European Professional Biologist" ensures a Pan-European Biological Competence towards the Public

ECBA's mission is set out in its constitutionary aims and objectives: (a) *to promote biological sciences and biological education*, (b) *to enhance the status of professional biologists*, (c) *to represent their views to the European Union*, and (d) *to ensure the competence of professional biologists by awarding the title 'EurProBiol.'*

This title was introduced in 1995 after two years of consultations between the national biologists associations of Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom.

Why is the EurProBiol title needed?

The European Directive 89/48/EEC is part of the "single market" legislation aimed at removing obstacles to the free movement of people and is concerned with the mutual recognition of professional qualifications within the European Communities. Its full title is "Council Directive on a general system for the recognition of higher-education diplomas awarded on completion of professional education and training of at least three years duration." It is referred to as the Directive on the Mutual Recognition of Professional Qualifications.

ECBA's analysis on the main entry requirements for the member grade of each national association revealed a great variation.

Although in each national association the entry is based on an academic degree, only four of the 12 European Countries then did have national *professional titles* for biologists, Ireland, Italy, Spain and the UK, hindering free movement in the unified work market.

The title 'European Professional Biologist' owned by ECBA, was launched in 1995 and is awarded to applicants, when three requirements are fulfilled: (1) an academic biological degree, (2) a period of professional experience in a biologically related job and (3) the applicant has agreed to abide by the EurProBiol Code of Conduct.

The recognized academic degrees in EC Member states vary in duration from approximately 3 to 5 years, and the requirements of postgraduate professional experience in countries with a professional title includes an additional period of 3 years with its formula:

$$3U + 2 (U \text{ and/or } T \text{ and/or } E) + 3E$$

ECBA recognizes flexible qualification routes for biologists in Europe. In this formula *U* represents a year (full-time) studying for a degree in a biological subject at a university, *T* represents a year of relevant training, and *E* represents a year of professional experience.

Each applicant is asked to describe and explain that he/she is (a) *able to apply his/her knowledge to a satisfactory standard in a biological related job*, (b) *knowledgeable about health, safety, environmental and other regulations relating to his/her job*, (c) *possessing a broad knowledge of experimental and other biological skills*, (d) *competent to plan and organize work to a satisfactory standard*, and (e) *able to make clear oral and written presentations and reports*.

The holder of the title has also to agree to abide by a Code of Conduct, which requires each European Professional Biologist to

- conduct himself/herself honourable so as to uphold the dignity and reputation of the biology profession
- keep his/her knowledge up to date, so that he/she is competent to practice as a professional biologist
- apply the highest scientific principles to his/her professional activities, and take into account the long term effect of those activities on the environment
- value and respect all living organisms and systems

This ECBA Code of Conduct is still under active discussion, especially the last point with regard to the developments at the beginning of this 21st century in the fields of crop plant manipulation (terminator technology), xeno-transplantation, stem-cell research and the different fields of reproductive biology. In June 2000 ECBA is organizing a workshop on bioethics, to get an answer to some of the most urgent ethical problems deriving from those new technologies which are beginning to remake the biosphere.

(3) ECBA Recognizes the Challenge to Educate and Train Future Biologists not only by Integrating Research and Practice of Science but also Public Needs and Trends

Professional biologists in Europe play already multiple roles in different fields. To improve the dynamic development, ECBA is trying to foster unity and the importance of a unified voice of biologists. As a professional body to promote biology as a service to the public ECBA regards a unified voice of biologists as a key element, particularly with regard to issues of public concern (like food quality (including food safety), environmental issues (clean

air, drinking water), *natural resources* (land use, sustainability), *education* (in schools, colleges, polytechnics and universities) *including bioethical issues* (genetically manipulated organisms, reproductive biology, pesticides, etc.).

To speak with authority ECBA regards it as essential that it comes in closer contact to the different learned biological societies in Europe, including IUBS. ECBA also will develop continuous relationships to the general public (consumer associations, political parties, parliaments) as well as to the life science industries. Aim is to have a cautious eye on fast-moving market conditions, the ultimate driving force in professional field developments. The employment of biologists created by the implementation of biological techniques in related industries is growing and reveals changing recruitment factors: *suitability of qualifications and skills, language abilities, adaptability to other cultures, international business experience, relocation allowance* and others.

ECBA is planning to develop a “Continuing Professional Development Scheme” to ensure that future EurProBiol title holder keep up to date and maintain their competence.

The benefits of continuing professional education and training are 3 fold: *employers see the competence of their employers increasing, employees are encouraged to fulfil their development needs and enhance their career prospects, and, the public remain confident that EurProBiol title holders are competent biologists.*

The recognized trends of further specializations of biology into very diversified research fields, the implementation of new biological technologies into production and the development of professional fields by political directives, laws or programmes, like the AGENDA 21, is signalling that the purpose for an “integrative biology” is - from a scientific point of view - a step in the right direction, but it is not enough.

It is absolutely necessary to analyse trends and new technological forces coming together with social forces creating a new basis for markets. And the consequences for higher education have to be evaluated.

A number of European reports indicate, that the increased use of technology not only offers a range of opportunities for economic growth but also requires a rethinking of human resources and the workforce with adequate qualifications and skills. Evidence points to a greater need for engineers and scientists. Biologists are hardly named. In the future biologists will have a more important role to play: it will be their century. But they will have to undergo profound changes in skill requirements: *from the ability to operate in well-defined and stable environments to the ability to operate in ill-defined and changing environments; from the capacity to deal with repetitive, straight forward and concrete processes to the capacity to deal with non-routine abstract work processes; from the ability to operate in supervised work conditions to the ability to handle decisions and responsibility; from isolated work to group and interactive work; from the ability to operate within narrow regional and time horizons to the ability to operate within expanding continental/global and time horizons.*

Both, the technological changes as well as the changes of necessary skills for future professional competence of biologists should be reason enough to direct these trends into biology education at the tertiary level which has the highest multiplicatory effect.

Initiatives in Europe induced by the SOCRATES/ERASMUS programme and aimed to qualify for *internationalisation, specialization* and *standardization* have been taken at a number of institutions. A Master-Course of Science and Environmental Technology after a Bachelor or Diploma degree, for example, is run as a 1 year European course involving Esbjerg University (DK), Fachhochschule Emden (D) and the University of Leicester (GB) with the aims to further (1) *understanding of the industrial and political developments in Europe and worldwide in relation to environmental questions*, (2) *Profound knowledge of environmental technologies*, (3) *Knowledge of environmental law and management in Europe*, and (4) *Environmental consciousness and safe behaviour on an international level*.

The teaching staff in this Master's Course - and this is the most relevant trend in professional biologist education - includes specialists not only from the participating universities but also from industry and extramural professional organizations.

In conclusion, the 21st century will bring exciting advances in a number of biological sciences and discoveries, which will lead to new applications in the fields of clinical therapies, diagnostics, plant and animal production, industrial uses and environmental problems, broadening and enhancing the professional areas for biologists.

Educating of biologists will need a basic fundamentum of knowledge about all levels of biological complexity before specialization, a specialization period diversified for those, who want to teach (generalists), to do fundamental research (highly specialised) or to work in upcoming applied fields. For all of them educational institutions will have to provide insight into economical, political and societal developments, to cope with trends, essential for professional success. To receive full acknowledgement as a certified biologist a period of professional experience will be needed.

The crucial problem for the new type of professional Master's degrees in life transforming technologies as well as for the "hot jobs" takers in the new life sciences industry will be their capability to regain public trust. A common effort of learned biological societies, educational organizations and professional associations is needed to make transparent what may be a potential benefit or risk. "Ethics and science need to shake hands" (R.C. Cabot, (1868 - 1939) in "The Meaning of Right and Wrong") is not enough today. The scientific community has to back a strong Code of conduct.

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