Revised Biology Curricula at Universities in Europe

European Communities Biologists Association

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REVISED BIOLOGY CURRICULA AT UNIVERSITIES IN EUROPE

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the European Communities Biologists Association
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FOREWORD

The publication of this revised edition of 'Biology Curricula at universities' coincides with the 40th anniversary of the discovery of the structure of DNA by Watson and Crick. During these forty years, we have seen an unprecedented expansion in our knowledge and understanding of biology and in the application of our new-found knowledge for the benefit of mankind.

As our knowledge had broadened and deepened, there has been a trend towards increased specialisation in degree studies, as new discoveries and concepts have been incorporated into the curriculum. However, it is important that students retain a broad knowledge base, including both the molecular and whole-organism end of biology, so that they are able to understand and contribute to future developments across the whole spectrum of biology. The revised curriculum described in this booklet has this need at its core.

The same decades have also produced an increased awareness of the impact of man on the biosphere, and the potentially catastrophic consequences of atmospheric warming, acid rain and the thinning of the ozone layer.
Professional biologists have an increasing responsibility to advise governments and the public at large on these issues, and to help formulate suitable long-term solutions. This task must be undertaken with authority and sensitivity, and requires competence in communication. Such skills are becoming as important as a grounding in the principles of biology, and must have a place in the curriculum.

Finally, the formation of a single European market has led to the need for harmonisation and an understanding of the equivalence of qualifications. The curriculum for higher education students in biology is central to this goal, and makes the publication of this revised curriculum especially timely.

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AIMS of THE EUROPEAN COMMUNITIES BIOLOGISTS ASSOCIATION (ECBA):

1. To represent the professional interests of biologists in the European Communities,
2. To ensure the professional competence of biologists within the European Communities,
3. To provide information on professional matters concerning biologists,
4. To promote cooperation between national biologists associations throughout Europe and to facilitate free movement of biologists within the European Communities,
5. To promote the exchange of those teaching biology in all classes of educational establishments,
6. To promote the recognition of the essential role of biology in education of the public at all levels of the education system,
7. To advice the EEC and the public in general on biological matters having implications for society.

1. INTRODUCTION

The European Communities Biologists Association (ECBA) is the international association of professional biologists in Europe representing the existing national associations of biologists in the member countries of the European Communities market. ECBA was founded in 1975 as a result of an urgent need for cooperation between a unified European body of different Biological Associations with the political and the administrative institutions of the European Community. Since 1991, ECBA has been registered in Belgium as an international association with scientific, educational and professional aims with its head office in Namur. ECBA aims, to represent the professional interests of biologists in the European Communities, to provide information and to promote cooperation on professional matters between national Biological Associations throughout Europe. ECBA will ensure the professional competence of biologists within the European Communities, promote the status of the profession of biology, and maintain a high standard of competence in all fields of professional activities. ECBA intends to develop a European Biologist professional qualification (Eur Biol) based on a high standard of education and an appropriate level of practical experience and competence. Therefore, the education and training of biologists remains a central and continuing activity of ECBA, furthering and improving the professional qualifications of biologists in Europe.

In 1976, ECBA's first workshop was devoted to "Biology Curricula at Universities". The thinking was that universities, through the combination of teaching and research, represented dynamic institutions where ideas about the function and importance of biology originated. They intluence both, the way biology is taught in schools and the way biologists act in other parts of society. Consequently, one of the first objectives of the workshop was to compare ideas about a core of biological knowledge taught at universities in particular with respect to the skills and attitudes necessary to apply knowledge. It attempted to define and agree upon the elements of a core-programme in order to achieve comparable levels of qualifications of university training throughout Europe.

The four main agreements of the 1976 meeting were that:

- Biologists should have a common basic training period (usually of 4 years) resulting in the acquiring of knowledge, skills and attitudes comparable in all countries concerned (" core programme"), allowing one to define a Biologist in a manner recognisable by all member associations.

- The university training of biologists should be 5 years in total, allowing for specialisation into different fields of biological profession, based on the core programme.

- The curriculum should allow the student to change his/her prospective field of specialisation, e.g. from teaching to research or vice versa.

- Four main directions of specialisation branch from the core programme namely teaching, research, biotechnical professions, and industry/public services.

Following other ECBA Workshops, e.g. *London* (1983) devoted to "Biologists and the Environment" and in Kollekolle (1984) to "Professional Biologists in Europe", further ideas for the qualification process of biologists were developed. Defining the professional fields of Environmental Biologists in land use planning, pollution control and conservation, clearly indicated that professional requirements in instrumentation, methodologies and capabilities should be added as elements and course components in environmental training programmes.

With the changing and broadening employment pattern of biologists, the possibility arose that study should include skills for the "adaptation to employment in new fields". This was especially the case with the development of "applied biology" and the use of biological "know how" in education, medicine, pharmacy, animal production, plant production, environment, industrial use, etc.
Additionally, the ECBA Workshop on "Competence of Biologists for Experiments on Animals" (Amsterdam 1988) recommended that biologists needed ethical training in addition to specialist knowledge.

Three advances created an urgent need to reconsider the biology curriculum of ECBA:
(a) ECBA's involvement in the recognition of training for biologists,
(b) the developments of basic research in the biosciences and
(c) the opening of new fields of applied biology.
The Netherlands Institute of Biologists (NIBI) prepared, arranged and hosted the second ECBA Workshop on "Biology Curricula at Universities in Europe" in Amsterdam in October 1992. This report is expected to help in discussion between all ECBA members on advancing biological sciences, developments in professional biological fields, the promotion of biology as a profession and the creation of a European Biologist professional qualification.

2. AIMS AND OBJECTIVES OF THE WORKSHOP

The 2nd ECBA-Workshop on "Biology Curricula at Universities in Europe" had the following basic aims:

exchange information about the present educational and training of biologists in

various states of Europe

discuss the professional standing of biologists in relation to their qualification

identify and define professional needs

consider improvements in basic and specialist training of biologists and

develop ideas about the implementation of a credit point system within the European University network.

The assembly of representatives of the member bodies of ECBA and experts from different countries concentrated these aims into two main objectives:

- To identify and to define the professional fields of biologists with their corresponding needs and the academic standing of biology at universities taking into account the increasing diversity of biological research fields

- To reconsider and update the core elements and course components necessary to specify a general biologist (the "basic core programme" of ECBA, 1976), and to discuss the "process of specialisation" leading to professional careers.

3. GENERAL CONSIDERATIONS

The opportunities for advancing the life sciences (including biological, agricultural and medical sciences) have never been greater. Many ideas, methodological approaches, techniques and skills have taught us to recognize and to utilize the productive capacity of the biosphere. The increase in technological societies on a global basis, competing for world markets, results in an increasing need for industries and business to be scientifically literate. (United Nations Conference on Environment and Development [UNCED]). The Earth Summit in Rio de Janeiro of June 1992 stressed the importance of a reorientation and reshaping of human activities to consider biological principles. This is needed to minimize environmental damage (pollution of air. soil and water, deforestation and reduction of biodiversity, global warming and shifts in climate) and to ensure that the process of global development is sustainable. AGENDA 21 (a comprehensive programme of action for the 21st century) identifies a role for bioscientists in universities, industry, government and elsewhere in increasing the biological input. The major problem areas that affect the future of humankind and civilization, include population growth, food, health, society and environment. Biology holds the key to understanding and to mastering these problems and biologists will be needed to solve them. Therefore Biologists will need efficient problem solving capacities. The recruitment of future biologists capable of making an effective contribution will rely on many components and training and these must be considered individually and in combination, to ensure biological literacy in its broadest sense.

3. 1 Basic research and funding

During the past decades, biological research has been transformed from a collection of single-discipline endeavours to an interactive science in which traditional disciplines of biology are bridged. Biologists have been aided by powerful new techniques and instruments, including gene technology, production of monoclonal antibodies, microchemical techniques (such as sequencing macromolecules), flow cytometry, magnetic resonance spectroscopy, and computer applications in data collection and analysis. All these achievements have produced synergistic interactions that have shortened the time between fundamental research and its application.

The main areas in which significant developments have occurred are:

(a) structural biology,
(b) genes and cells,
(c) developmental biology,
(d) neurobiology and behaviourial sciences,
(e) immunology and infectious diseases,
(f) evolution, biodiversity and systematics,
(g) ecology and conservation biology, and
(h) plant biology and agriculture.

The principles of physics, chemistry and biology that apply to living systems (ranging through entire ecosystems, organisms, cells and organelles, and biomolecules) provide the core of biological function. The main role of biologists is to elucidate these basic principles and determine how they are utilised to produce the diverse world which humankind inhabits. This will be achieved by ensuring that new and creative advances of research are encouraged and supported. Funds are needed to provide specified equipment as well as providing the basis for long-term and start-up projects by qualified research institutions and individual investigators.

3.2. International Cooperation

Basic biological research in Europe has appreciable links to applied areas, e.g. health and agriculture. The "New Biology" with spectacular advances in recombinant DNA techniques, monoclonal antibody techniques, and microchemical instrumentation has opened new opportunities for exploring both fundamental and applied biological problems. The techniques of molecular biology allows us to analyze the effects of designed changes in the amino acid sequence of en2ymes on structure and catalytic function. This has direct application to the development of improved therapeutic drugs and products for agriculture and the food industry. As result some confidential and secret research programmes have been created impairing international cooperation. Progress in biological sciences however is stimulated by an open and synergistic global interaction of bioscientists in different research fields with free exchange of information, and by facilitating an interactive environment for research.

There is, additionally, a need for close collaboration between the organized learned societies of biology and the organizations of professional biologists at a national and a European level. The general aim is to foster unity in biology as a key element for dealing with issues of common interest and of public concern. Consensus is needed especially to set standards of competence and conduct, amongst biologists in different professional fields. The unification process of Europe provides an imperative to maintain a high professional standard of biologists in each individual EC state with consequences both for the length of education and training, and the nature of the qualification process.

33. Professional Performance and Employment

The European Single Market is also a European Single Labour Market. The Community Charter of the Fundamental Social Rights of Workers adopted by most Heads of State at the European Council on Dec. 9, 1989 states that "High-quality basic education and vocational training are essential if the citizens of the Member States of the Community are to meet the new challenges and take advantage of the new opportunities. They are real investments. The future of the Community depends on the skills and performance of its working population".

In excess of 200 000 professional biologists in Europe are currently perfonning their tasks on very different bases in each of the EC member states as well as in other European countries. Biological professions are regulated in some European countries, but not in others. Employment patterns also vary widely, ranging from teaching biology in basic and secondary schools, to providing a mixture of teaching and research of biological sciences at universities and polytechnics, to research in industry, public and private institutions to biological advice or control functions in a variety of situations.

Their functions includes basic research, research and development, production and quality control and management, health care, land use planning, conservation and pollution control. The increasing commercial development of biotechnology has opened many prospects for biologists in human health care, animal production and plant agriculture. Such activities require several types of well-trained and experienced people including specialists in r-DNA-technology, molecular biology, immunology, microbiology, biochemistry, bioprocessing, enzymology and cell culture. In other working fields, specialists such as ethologists, ecologists, taxonomists, entomologists are also needed. Adequately trained scientific and technical people are vital to any industrial development. Biologists should be creative, versatile, dynamic, innovative and able to communicate. Because biology is a multidisciplinary science, biologists need also to be interdisciplinary, communicating with engineers, chemists, economists and computer-scientists. This requires adequate training in the relevant curricula, and personal skills and awareness.

3.4. Biological Literacy of the Public

Biology as a science and the applications of biotechnology are becoming more and more a focus of public awareness and concern. Biology can no longer be regarded as a scientific or technical tool to improve human civilization, and used only in scientific, industrial and commercial activities. Applied biology and biotechnology influence the social, cultural and environmental factors and the general public needs to understand scientists, science and its applications. Informed debate requires a basic biological education.

Biological literacy is not achieved however by memorizing the definitions of scientific terms, but includes the ability to:

(a)	understand	biological principles; impact of humans on the biosphere; scientific inquiry; historical development of ideas;
(b)	value	scientific habits of mind; biodiversity; biology and biotechnology in society; importance of biology to the individual;
(c)	be able to	think creatively; reason logically and critically; understand the basic principles of technology; make personal and social decisions; apply knowledge to solve problems.

Biological literacy, a subset of scientific literacy, is a lifelong, continuous endeavour. The US-Biological Sciences Curriculum Study (BSCS) Group (Colorado 1960 proposed a mode of biological literacy that includes four distinct levels:

(a) a nominal level of literacy, literate in name only, in which individuals recognize biological terms as being related to natural phenomena, but are unable to provide adequate explanations of the phenomena and even carry misconceptions about them;

(b) a functional level of literacy, in which individuals are able to define terms correctly, but the ability is based on memorization of information with little understanding;

(c) a structural level of literacy.in which individuals can construct appropriate explanations based on their experiences and are able to explain concepts in their own terms;

(d) a multidimensional level of literacy, in which individuals can apply knowledge gained and skills developed to solve authentic problems that may require the integration of information from other disciplines such as sociology, economics, and political science.

Biology literacy for many means information, facts, topics, discipline-specific concepts. To restrict biology to a body of knowledge, would negate its integrative nature and restrict the possibilities of:

emphasizing inquisitiveness, self-confidence, a critical attitude, and an open mind towards others and the environment:

relating biological knowledge to personal experience;

fostering the development of a scientific approach without dissociating cognitive aspects from socio-affective ones.

The objective of biological literacy is to design an effective biology education, which places the major themes of biology in a workable conceptual structure. Nine themes or unifying concepts of biology were developed by BSCS as early as 1960, and they remain valid today:

1. Change of living things through time: evolution
2. Diversity of type and unity of pattern in living things
3. The genetic continuity of life
4. The complementarity of organism and environment
5. The biological roots of behaviour
6. The complementarity of structure and function
7. Regulation and homeostasis: preservation of life in the face of change
8. Science as inquiry
9. The history of biological concepts.

Major themes, levels of organisation and educational behaviours can be placed matrix to and the design of biological curriculum:

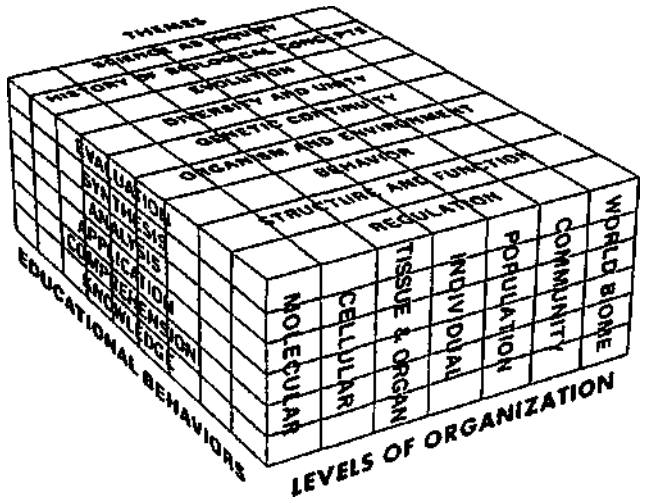

figure 1. The BSCS-matrix for the design of biological curriculum materials (circa 1960)

3.5. Training and Education

The dynamics of diversification in the biosciences and the development of the employment profile of biologists requires, not only a broad knowledge of the many areas of biology, such as molecular biology, developmental biology, and ecology, but also other scientific disciplines, such as chemistry, physics, and engineering. Biology is becoming more chemically and physically orientated. In many areas, training requires an increasing focus on chemical and physical technologies. This is especially important for work in structural biology. Similarly, evolution and biodiversity, systematics, population biology, and ecosystem studies require an increasingly interdisciplinary approach that includes training in molecular biology, computer sciences, and mathematics. Also ecology, evolutionary biology and systematics require scientists trained in a greater variety of subjects. Favourable educational developments should be encouraged by special training-grant programmes targeted towards these fields of biology. A problem field is systematics since only a few individuals can identify organisms from different parts of the world, especially the tropics.

To maintain professional competence, the standards of training for biologists must be continuously developed and programmes for in-service training are needed to help to maintain excellence and broaden knowledge. It is essential for each biologist to establish close relationships with the scientific community, businesses, industries, as well as professional bodies.

3.6. The Role of a European Professional Body

Professionals should receive from society, the right to regulate themselves and to determine and judge the members of their own professional body. Both national and international biological associations, have a continuing responsibility to question, amend and revise the goals of their profession. Scientific knowledge, business skills and professional commitments are the key issues. In the European context a climate of trust is needed: the harmonization of qualifications throughout Europe will take some time and exchange programmes throughout Europe will help this process. There should be a common aim to facilitate the abilities of biologists to use their knowledge and skill for the advancement of human welfare and to contribute to public education. It is the aim of ECBA to facilitate this aim.

4. BASIC TRAINING OF BIOLOGISTS PRIOR TO SPECIALISATION

4.1. Introduction

A core programme is fundamental. A trained biologist, prior to specialisation, must have a basic insight into structure, function and evolution at the four main levels of biosystems: molecules, cells, organisms and populations. He/she must also have an adequate grounding in the physical sciences and mathematics. Thus the basic core gathered by a biologist during the initial training period must include certain aspects of chemistry, physics and mathematics. In this way, a trained biologist will be equipped to handle the diversification and unity of biological phenomena.
A core-programme for the basic training of biologists is outlined below. It is expected that the knowledge acquired during the study of the core programme will result in, and be associated with, a range of techniques, skills and attitudes. It should be noted that the subject headings listed in the core-programme are arbitrarily arranged. Students should cover all the aspects of the biological and related disciplines specified in the core programme, though the depth to which the different aspects are treated will depend on the situation in each university and on the proposed differentiation and future specialisation, of the student.

4.2. Topics to be included in the core programme

A. Biological topics
Systematics of organisms
Diversity, taxonomy, phylogeny, knowledge of major phyla and classes, including palaeobiological groups. A more detailed knowledge of the systematics of selected groups.
These studies should include taxonomic principles and techniques and lead to a familiarity
with the local flora and fauna.

Structure and function of cells and subcellular systems of prokaryotes and eukaryotes.
Ultrastructure and biochemistry of cells and their organelles; accumulation and exchange of solutes and water by cells; unicellular and multicellular grades of organization; communication between cells; movement and differentiation of cells; cell division, growth and ageing; interaction between cells and viruses; origins of life.

Developmental biology
Gametogenesis, growth and development, ontogenesis, phylogenesis, abnormal growth.

General and comparative physiology
Metabolism and its regulation; mechanisms of flow of energy and matter, including photosynthesis; nervous, endocrine and immunological communication and integration systems; reproductive physiology; neurophysiology and sensory physiology; responses to stimuli in plants; biocybernetics.

Ethology
Patterns of behaviour e.g.: feeding, courtship, mating and conflict; modification of behaviour e.g.: ontogeny, genetic and environmental determinants; behaviourial ecology.

Genetics and evolution
Organization of genetic material in prokaryotes and eukaryotes; patterns of inheritance and variability; DNA-structure and duplication, RNA-replication and protein synthesis; gene action, mutability, control and modification; sexual recombination and sources of evolution e.g.: genetic polymorphism, genetic drift, selection, isolation of populations, speciation; population genetics.

Ecology
Levels of ecological organisation of the biosphere e.g.: ecosystems, communities, populations, individuals, symbiosis; population growth; methods of control and regulation of populations, (including those of humans); host-parasite dynamics; renewable and nonrenewable resources;
productivity e.g.: food chains and webs, trophic levels, energy flow, nutrient cycles; role of microorganisms; pollution; human action on the environment, biogeography.

B. Topics related to biology

Mathematics
Basic knowledge of statistics, theory of functions, analysis, theory of sets, and general systems theory

Chemistry
Basic knowledge of general chemistry, particularly organic chemistry.

Physics
Basic knowledge of physical disciplines, and particularly biophysics, instruments and methods in physical research relevant for biology

Geosciences
Basic knowledge of stratification, palaeontology including palaeo-botany and -zoology, dynamics of biosphere.

Ethics
Basic knowledge of ethical principle, awareness of the responsibilities of a biologist in fields of research, biotechnology, environment and health.

Philosophy of science
History of biology, methodology of research, the problem of truth, classification of the sciences, the problem of reductionism, methods of explanation.

Computer skills
Basic knowledge of use of computer for modelling and analysis.

Languages
English.

43. Skills and attitudes to be included in the core programme.

The following skills and attitudes are essential constituents of the core programme of biology. Some are specific for a biologist, some are necessary or desirable requirements for all scientists which also pertain to biologists. The structure of syllabuses has considerable influence on the development of skills and attitudes.

A. Basic skills
Necessary skills for a biologist:

The use of classical and advanced biological and instrumental techniques.
The use of newly developed techniques
Experimental skills (planning, performing and evaluating experiments).
Mathematical skills (use of statistical techniques for collecting, evaluating and presenting biological data, special forms of diagrams and logarithmic scales).
Verbal and reporting skills (discussion techniques, lecture techniques, techniques
of writing scientific texts).
Bibliographical techniques (reading techniques, use of libraries and databases).
Observation techniques (intellectual skill towards separation of syntactic and semantic aspects of data i.e. of sensory experience and interpretation).
Hypothesis techniques (solving of problems by forming hypotheses that can be tested by empirical data).
Methodological skills in science (at least the clear distinction of: causal explanation/teleological explanation, deductive/inductive thinking, linear causal/complex thinking in causal networks).
Computer skills (modelling of complex systems).

Desirable skills for a biologist:

Awareness of developing future techniques.
Drawing skills (diagrams, cross sections, microscopical and macroscopical models,
use of computer).
Application skills (application of biological knowledge to problems of everyday life
by means of associational thinking)

B. Basic attitudes
Necessary attitudes for a biologist:

- Tendency to generate empirical proof with data.
- Readiness to test formal theories for use in biology (e.g. theoretical physics,
- theoretical chemistry, mathematics, general systems theory or philosophy of
- science).
- Awareness that biology is a complex subject and needs a particular standard of training in complex thinking and of wide-ranging knowledge in different fields.

- Openness to new aspects of biology and to innovations in the biological sciences and for continuous learning and re-learning.
- General cautiousness in changing biological systems.
- Openness in the terms of cooperation, teamwork and interregional and international exchange.

Desirable attitudes for a biologist:

Willingness to promote the use of biological knowledge for the benefit of society.

A biologist should develop bioethical standards during his/her study. He/she should not make unwarranted or uninformed statements, maintain a professional attitude and competence, and maintain the dignity of biology and science.

4.4. Duration and structure of the Core Programme

The core programme should occupy up to 4 years of study, including time spent on subjects related to biology. The complete training of biologists may also include periods of specialised biological study (differentiation and specialisation: [section 5 and section 6]), which may, in part, overlap with the core programme. There is a need to develop a European Credit point system to compare and harmonize the quality and equivalence of biology curricula within the European Communities.
The teaching methods recommended to implement the study of the core programme include well known techniques such as lectures, projects, seminars, laboratory exercises, training in research, field studies, and new training techniques, relevant to the study of biology. We wish to stress that biological studies are only possible if there is practical work and appropriate access to living material.

Knowledge, skills and attitudes in the biologists training should not be seen separately from each other or from the core programme, but are interrelated in a very delicate way. It should be realized that a purely cognitive training restricted to knowledge, judgements and laws is not effective in professional life, and so should not be the objective of university training. Cognitive training, however, should be accompanied by training in skills and attitudes as it will then have greater chance to be applied and to remain accessible in long-time memory. Hence the qualification gained by the basic training of a biologist should be judged simultaneously by three dimensions. This does not exclude however, the possibility that basic knowledge (part 4.2) will be emphasised more at the beginning, whereas basic skills and attitudes (part 4.3) will feature more at a later stage of the studies.

5. THE PHASE OF DIFFERENTIATION AND ORIENTATION PRIOR TO SPECIALISATION

5.1. Introduction

In the previous chapter "The basic training of biologists prior to specialisation", an overview is given of all topics, skills and attitudes that a biologist should have to be able to act as a professional. The knowledge base in biosciences is growing and developing very fast (a doubling every 5 years), and the curriculum must on the one hand reflect the necessity of offering insight to the total core programme and, on the other hand, cover this extending knowledge in specialised fields within the biosciences. Before commencing with a specialisation the core programme should fulfil both these somewhat contradictory pathways. This can be achieved by elaborating the core programme in particular ways prior to specialisation. We call this the "differentiation phase".

In the core programme most of the topics can be taught in a theoretical way, including physics, chemistry, mathematics, ethics, and the acquisition of skills and attitudes should be taught in the differentiation phase of the curriculum and involve both theoretical and practical studies.

5.2. The Status and Organisation of Biological Professionals in Europe

Before discussing the specialized training of biologists reflection on the situation of professional groups in some European countries is necessary.

In Italy all professional biologists are organised in the 'Ordine Nationale dei BiologT. If a biologist wants to work as a professional, he/she must be a member of the Ordine.

In the UK, the biological profession is regulated under Directive 89/48/EEC The professional title 'Chartered Biologist' may only be used by those persons who are Members or Fellows of the Institute of Biology. Entry to Membership or Fellowship requires a minimum of 3 years training at a university and a further 3 years of professional experience or training. The Institute also administers a number of professional registers, including those for Environmental Biologists, Biologists in Health Care, Accredited Nutritionists (jointly with the Nutrition Society) and Qualified Persons in the Pharmaceutical Industry (jointly with the Royal Society of Chemistry and the Royal Pharmaceutical Society of Great Britain). Professional biologists are often members of 'learned societies' and approximately 80 societies are affiliated to the Institute of Biology. Biology teachers in state secondary schools are regulated directly by the state.

In Denmark, there is no registration of professional groups. Everyone who has acquired a university degree is considered a Biologist. Applicants for employment are evaluated on their individual merits. Likewise, those biologists who establish firms, survive in the market on their personal qualities and qualifications.

In France a strong emphasis is directed to teachers in secondary schools. They need to fulfil all legal demands.

In the Netherlands the only legally-registered group of professional biologists are teachers in secondary schools; these professionals have not necessarily finished a Ph.D. in Biology, but have, after finishing their biology degree at a University (Drs), fulfilled a one year professional specialisation to become a teacher. Other professional biologists are voluntarily grouped in learned societies. Most biologists working in research, whether in industrial and institutional laboratories, or governmental funded institutes have a Ph.D.-degree from the Universities.

From these examples, it is clear that the situation of Biological Professionals is quite different in the varied European countries.

53. Differentiation within Core Programme

It is clear that professional biologists need a common core curriculum during their University training, since they need the many attributes that are necessary for biologists. These are (1) a broad knowledge of the bioscientific field as a result of cross-fertilisation between biological specialisms, (2) a broad knowledge of the diversity of organisms, (3) the ability to interface with specialists from other sciences, such as chemists, physicists, mathematicians, physicians, politicians, (4) knowledge and insight into the complexity of molecules, cells, organisms, populations, and ecosystems.

Specialisation, during and after the core programme results in biologists of great diversity and this training produces professionals who will be valuable in future technological employment.

The core programme of the biology curriculum at university is a broad and profound extension of the biological knowledged taught in secondary schools.

By introducing a degree of specialisation (differentiation) in the university curriculum a smooth link will be formed between the core programme and the specialisation/ professionalisation of the student. During this differentiation phase, courses are more-or-less concentrated around some main topics in the field of biology. All necessary skills and attitudes are taught in both theoretical and practical courses. The possibility should exist for students in this part of the curriculum to switch from one topic to another and there should be not too many topics. Some good examples of topics which can be identified with groups of professions are:

a. general biology differentiation, preparing for specialisation as biology teacher, policy maker or public relations officer;

b. ecological/environmental differentiation, preparing for specialisation as researcher in ecology/environment, population-ecology, marine-biology or ecotoxicology, environmental consultant, environmentalist, plant- or animal organismal biologist;

c. physiological and biochemical/molecular differentiation, preparing for specialisation as an animal- or plantphysiologist, geneticist, microbiologist, developmental biologist, neurophysiologist, toxicologist, biophysicist, cell or molecular biologist, biochemist, plant/animal- biotechnologist;

d. medical differentiation, preparing for specialisation as biologist in health care or a researcher in human physiology, medical biology, oncology, immunology or nutrition;

These differentiation branches will prepare students for a further specialisation into fully trained professional biologists.

5.4. Differentiation in the core programme in terms of skill of research and as a preparation for specialisation

The basic goal of the curriculum is to equip the student with knowledge of all topics, and the skills and attitudes defined in the core programme. The differentiation phase offers the possibility of initial specialisation within the curriculum and can prepare for further specialisation in preparation for a profession.

This initial specialisation in the curriculum equips students, who may not became a professional specialist, to play a number of roles in society where a Ph.D. or fully trained professional, is not required. Initial specialisation allows an appreciation of research in a laboratory, or working within a governmental, policy making situation, or employment in a consultancy, and so on. Initial specialisations may be undertaken in the laboratories of foreign universities and institutes by using exchange programs such as Erasmus and Comett.

Since there are employers who require well educated people who can solve problems, but who do not require a Ph.D. or professional qualifications, this curriculum prepares some of the student cohort for employment in a wide range of jobs.

5.5. A dynamic University curriculum

The structure of the curriculum outlined in this booklet is much more dynamic than the static 'flower'-like curriculum described in the 1976 ECBA-booklet "Biology Curricula at Universities" and looks like a tree, rooting in the secondary school, having a trunk that is the uniform part of the core programme in the curriculum, with some main branches that form the differentiation phase leading to small branches and twigs which result in specialisation into a fully trained professional.

This model is not only dynamic in curriculum structure, but also dynamic in time. The Uniform phase of the core programme rooting, when possible, in the secondary school biology curriculum may therefore vary in time, but will be at least a two year period, but may be intermingled with the differentiation phase.

This University biology curriculum points to the urgent need for harmonization of secondary school biology curriculum throughout European countries.

6. FURTHER SPECIALISATION

The core programme and initial specialisation is insufficient for full professional training. A phase of further specialisation is necessary to train biologists to the highest level. Students of biological sciences should undertake additional advanced studies of at least 1 year and ideally should include a period of biological research and/or problem orientated project studies. This will enable the student to identify and to solve problems and to assess scientific results.

The significant increase in the depth and breadth of biological knowledge and understanding and their applications for the benefit of mankind has led to the development of many professional biology fields. Each requires some particular expertise and in this chapter we aim to summarize the knowledge, attitudes and skills associated with the major fields of professional biologists.

6.1. List of major fields of professional biologists

a. Biologists working in basic biological research
b. Biologists working as teachers
c. Health research workers
d. Hospital laboratory technicians and clinical analysts
e. Biologists working in the pharmaceutical industry
f. Biologists working in the field of public health
g. Biologists working in health education
h. Advisers in health and safety in the workplace
i. Agricultural research workers and advisers
j. Environmental research workers
k. Environmental consultants, advisers and auditors
l. Advisers and workers in environmental conservation
m. Advisers in natural resource utilisation
n. Advisers in planning, development and land reclamation
o. Biologists working in manufacturing industries
p. Biologists working in sales, marketing and service industries
q. Advisers on government policy

a. Biologists working in the field of basic biological research

For the biologists who undertake research in the major biological fields (taxonomy, physiology, cell-molecular developmental biology, genetics, parasitology , entomology, ecology, ethology etc.) there is a need for further study where the student acquires deeper knowledge and skills related to developing a high degree of competence as an experimental and/or investigative scientist. Developing the borderline between biology and other sciences (physics, chemistry, mathematics, etc.) is particularly important.

b. Biologists working as teachers

Specialism in teaching is of the greatest importance for the future of biology and its place in society. Students who intend to teach in basic and secondary schools should become familiar with the didactics of biology including: theory of educational objectives, methods of evaluating, psychology of learning and development, sociocultural factors and curriculum theory. In addition students should further spear in human biology and, where appropriate, environmental biology. Competent teachers must also understand the sociology of education, interaction research, pedagogical theories and psychology in relation to different schools. There topics should not be dealt with solely in the form of lectures, but should be offered in connection with seminars and practical work in schools. The proportion of didactics of biology to general educational studies should be at least 2:1. Both together should cover about 2/3 of the period of further specialisation in order to guarantee a minimum amount of time spent upon human biology.

c. **Health research** workers

Most of the major advances in medical and health sciences have been achieved by close cooperations between research biologists and medically qualified practitioners. Medical research workers and clinical analysists are specialists in a wide variety of biological disciplines including: microbiology, biochemistry, molecular biology, genetics, parasitology, immunology, cytopathology and pharmacology. In addition they must be competent in data analysis, instrument operations and interpretations and in the management of complex inter-disciplinary groups of scientists.

d. Hospital laboratory technicians and clinical analysts

Effective health care relies on efficient and accurate analyses of biological material. Frequently the biologist is responsible for obtaining samples to be tested and for the correct interpretations of the results. Sometimes complex analytical instruments have to be used and maintained. Similar activities are undertaken in veterinary clinics. Technicians are often specialists in one or more of the following areas: clinical microbiology, clinical biochemistry, toxicology, parasitology, haematology, microscopy and cytology but must also be able to understand and cooperate with medically qualified doctors and their patients.

e. Biologists working in the pharmaceutical industry

The development, testing and production of drugs for human and animal use requires the cooperation of a variety of scientists. The role of biologists is critical in investigating and understanding the effect of drugs on human function and is regulated in many countries (Directive 75/319/EC, for instance). Specialist knowledge and training is required in pharmacology, epidemiology, human physiology, toxicology and appropriate aspects of organic chemistry.

f. Biologist working in the field of Public Health

Biologists working in public health are concerned with the provision of microbiologically safe food and drinking water. They also have important roles in organising and mentoring the disposal of organic effluents and health safety at bathing beeches. These specialists may be employed either in the public service or in commerce and industry. These disciplines especially include important competence in the use of instruments, microbiological and chemical analysis, epidemiology and toxicology and relevant aspects of the law. Many different specialists are involved in public health and biologists must be able to communicate effectively with them and the general public.

g. **Biologists working in the field** of **health education**

The dramatic improvement in public health has been due in no small part to ensuring people understand the importance of personal hygiene. Knowledge of human disease, epidemiology, psychology and excellent communication skills are vital to ensure that biologists can undertake this task efficiently.

h. Advisers in health and safety in the workplace **in industry**

Although all scientists have a responsibility for health and safety there is an important need for specialist biologists who are trained to assess risk, ensure they are minimized and that all workers are adequately trained and organized. Safety officers require knowledge appropriate to the work being undertaken (microbiology, chemical analysis etc.) but must also be able to inform others and ensure that relevant laws are enforced en observed.

i. Agricultural research workers **and** advisers

The professional skills and competence of biologists are central to the remarkable and continued success of this productive sector. Within the boundaries of Europe food is produced in excess of requirements and attention is turning to improving the efficiency of production, impact in the environment and the role of advanced techniques such as genetic manipulation. Research workers and advisers of the highest calibre are employed and must have appropriate skills and experience to undertake this vital work.

j. **Environmental** research workers

People now understand that their economic and agricultural activities are causing significant damage to the biosphere. Countries will continue to pollute the environment because of their industrial activities and biologists must be able to investigate and understand the complexities of incidents and recommend alternative actions and solve problems. They need to be professionally trained biologists with special skills in ecology, organism physiology, toxicology, economics and management.

k. Environmental consultants, advisers and auditors

Care of the environment is now regulated by a wide range of regulations and laws. Both public bodies and private industry often need specialist advise in helping them to monitor and/or solve environmental problems associated with their activities. Environmental biologists who give advise must be aware of all relevant legislations and be able to monitor environmental parameters. They must possess **a** high level of written and oral communication skills and be independent of the vested interest of polluters.

I. Advisers and workers in environmental conservation

The protection of natural habitats by designating them as native reserves requires that they be effectively managed. This requires regular surveys, and the development and execution of conservation management plans. Only professional biologists can organize this work and they require skills in taxonomy, ecology and practical management techniques.

m. Advisers in natural resource utilisation

Many raw materials used in industry are produced or obtained from 'natural' environments, such as forests, seas, lakes and rivers. The exploitation of natural environments must be very carefully managed to ensure they are not over-exploited and unreparable damage is done to the balance of nature. Advisers must be skilled ecologists but also able to undertake surveys and to understand economic aspects, legislation and to communicate with other specialists and governments.

n. Advisers in planning, development and land reclamation

People continue to use and develop land and such activities frequently produce a conflict of interest between economic activity and the welfare of plants, animals and ecosystems. Decisions relating to land use planning are often complex and taken within **a** legal framework. Biologists acting as advisors and consultants, or employed in planning organisations, must have good ecological skills and be aware of relevant legislation. They must also be able to represent the view of biologists in legal proceedings, such as planning enquires.

o. Biologists working in manufacturing industries

The knowledge and skills of biologists are necessary for **a** range of industrial enterprises including: fermentation technology, drug products, food processing and the emerging biotechnology industries. In addition to the necessary specialized biological skills people need to be able to work and communicate with engineers, quality control analysts, economists and managers, and marketing experts.

p. Biologists working in sales, marketing and service industries

The products of 'biologically bared' industries have to be sold and perhaps kept in good working order. These jobs are often undertaken by biologists and they require additional skills of marketing and the technical expertise to understand how instruments work and how they may be maintained and repaired.

q. Advisers on government Policy

Many government initiatives in health care, environmental protection and generating wealth have important biological parameters. Governments also sponsor significant basic research and decisions have to be made regarding priorities and topics. More and more biologists play a major role in such decision making at local, regional, national and international levels and they must have a broad knowledge of biology and excellent communication skills. The ability to quickly understand and analyze complex situations is essential and the skills of biologist in integrating data from a wide variety of sources make them well suited to act in this field.

6.2. Training in Special Institutes

The University biology curricula can respond only slowly to the developing professional needs. The scientific community, however, through national and international organisations and private institutions, offers a wide range of graduate and postgraduate courses relevant to applied and professional fields of biologists and they should be fully utilised.

ECBA recommends the establishment of more initiatives for professionally relevant and specialist qualification courses in biology specialisms throughout European countries.

CONCLUSIONS AND RECOMMENDATIONS

- All biologists in Europe should have a common basic training (core programme) period of minimum of 2 years, but recommended 4 years, resulting in a level of knowledge, skills and attitudes comparable in all countries.
- The complete University training of biologists should be a minimum of 3 years, but recommended 5 years, in total, allowing for a specialisation into different fields.
- There should be no attempt to devalue the currency of this basic 'raining in biology by pressuring institutions or individuals to complete training in inappropriately shortened periods.
- The core programme in biology requires study and experiences with living organisms so that students achieve insight into a complete spectrum of biological sciences, biodiversity and all levels of biological complexity, from the cell and subcellular level to the level of ecosystems. These studies should include the use of experimental methods of inquiry in the laboratory and field, and applications of biology to technology and society.
- The core programme should include at least a minimal of study of chemistry, physics, earth sciences, mathematics and statistics, emphasizing their relationships to biology.
- Topics relevant for professional performance should be included, such as policy and decision making, public administration, problem solving case studies, programming, operational research, law, economy and management.
- The specialisation period of a biology curriculum leading to research, teaching or applied fields of biology should be of the same high standard. All directions of specialisation are equally important.
- The programme of study for professional biologists should provide opportunities for studying the interaction of biology and technology, biosafety and the human and ethical implications of developments such as embryonic research, herbicide resistant plants, patenting life, genetic screening and engineering, cloning, human organ transplantation and marketing.
- The spectacular applications of sophisticated research methods in biological sciences has resulted in the emergence of a number of european centres for biosciences and technology, offering courses and flexible training programmes for biology students, doctoral and postdoctoral fellows and established scientists. Opportunity to qualify in a specific field, method or interdisciplinary area should be encouraged and acknowledged as a valuable component of university degree.

- The need is recognized to develop a credit point system for the study of biology in Europe to harmonize the diversity of qualifications and solve the difficulty of equivalence within the European Communities.
- The need is recognized to establish more initiatives for professionally relevant and specialist qualification courses in biology specialisms throughout European countries.

Tabel la. Summary of the general figures of the (pre-)curricula of biologists.

	Country	Belgium	Denmark	France	Germany	Greece	Ireland
1	Years of basic/secondary school from the age of 12 years - with biology - with mathematics - with physics - with chemistry	6 0-6 6 5 4	7 3-7 6-7 5-6 5-6	6 6 6 5 5	7 3-6 4-6 3-6 2-5	6 6 9 6 6	6 3-6 6 3-6 3-6
2	Entry age of students	18	18-19	18	19-20	18	17-18
3	Degrees (Estimated number of denominees in 1990)	License (350) Dr. (=Ph.D.) (4(H))	Bachelor (-) Master Sc. (I(X)) Dr.Sc(=Ph.D.) (25)	LiccnciC (35(X)) Master (3(XX)) Dr. (=l>h.D.) (3(X))	(from 1986) Slaalsexamcn; (teaching) (1200) Diploma (1963) Dr.rer.nat. (=Ph.D.): (686) Dr. Habil: (?)	Lie. (?)	B.Sc (= Hons) (300) M.Sc (50) Ph.D. (65)
4	duration of the curriculum: number of years years (after other degree) until Ph.D.: number of years	Liccnsil: 4-6	Bachelor: 3 Cand. scient. (=M.Sc.): 5 Ph.D.: 2-3	Bachelor (=Liccnci6): 3-4 Master: 4-5 Dr.(=Ph.D.): 8-9	Diploma: 5 Dr.rer.nat. (=Ph.D.): 34 Dr.Habil: (after Ph.D.) 4-6	Lie: 3.5	B.Sc(Hons): 4 M.Sc: 5-6 Ph.D. (after B.Sc): 34

ad 1. There are many differences in "secondary schools" in the European countries: e.g. in Germany it is starting at 12 years, in Portugal at 15 years;
The number of years with biology and other subjects can vary much more than indicated: indicated is only the situation for pupils going into higher education in biology,
In Denmark biology, physics and chemistry arc integrated objects in primary school (13-15 years);

ad 3/4 In Denmark a bachelors-curriculum Ls starting in 1993.

Tabel lb. Summary of the general figures of the (prc-)curricula of biologists.

	Country	Italy	Luxembourg	Netherlands	Portugal	Spain	United Kingdom
1	Years of basic/secondary school from the age of 12 years - with biology - with mathematics - with physics - with chemistry	6-7 3 6 3 3	6 3-4 6 5-6 4-5	5-6 4-5 5-6 2-5 2-4	6 5 6 2-5 2-5	6 4-6 4-6 2-4 2-4	6 6 6 6 6
2	Entry age of students	18-19	18	17-18	18	18	18
3	Degrees (Estimated number of denominecs in 1990)	Diploma di Laurea (2200) Dottorato di Riccrza (=Ph.D.) (?)		Bae.(=Teachcr 2e degree) (150) Doctorandus (600) Doctor (=Ph.D.) (70)	Licenciado (300) Mestre (?) Dovtor (=Ph.D.) (?)	Liccnciatura (?) Doctorado (=Ph.D.) (?)	B.Sc. (6000) M.Sc. (1000) M. Phil. (?) Ph.D. (2000)
4	Duration of the curriculum: number of years years (after other degree) until Ph.D.: number of years	Diploma di Laurea: 5 Dottorato (=Ph.D.): 3		Baa: 4 Doctorandus: 4 Dr. (=Ph.D.): 4	Liccnciatura: 4-5 Mestre (=Lic.+2): 6-7 Dovtor (=Ph.D.): 4-6	Liccnciatura 4 Doctorado (=Ph.D.) 3	B.Sc: 34 M.Sc: 4-5 Ph.D.: 34

ad 1. There are many differences in "secondary schools" in the European countries: c.g. in Germany it is starting at 12 years, in Portugal at 15 years;
The number of years with biology and other subjects can vary much more than indicated: indicated is only the situation for pupils going into higher education in biology. ad 3/4 In Italy is starting in 1993 a curriculum for the Diploma Intermedio Universitarrio of 3 years.
Luxembourg has no biology-university; students form Luxembourg are going to Belgium, Germany or France.
In Spain the 20 faculties arc changing the curricula according the new regulation.

Tabel Ic Summary of the general figures of the (pre-)curricula of biologists.

	Country	Austria	Finland	Norway	Sweden	Switserland
1	Years of basic/secondary school from the age of 12 years - with biology - with mathematics - with physics - with chemistry	6 3-6 6 3-6 3-6	6 7 ?	6 4-6 4-6 4-6 4-6	7 6 7 7 6-7	7 5-7 8 2-3 2-3
2	Entry age of students	18	18	18	19	18
3	Degrees (Estimated number of denominccs in 1990)	Diploma (including teaching) (400) Ph.D. (100)	Cand.Scient. (?) Doctor Scicnt. (=Ph.D.) (?)	Candidal us Magtstcrii (2(X)) Candidal as Scientiarium (50) Doctor Scicntiarum (?)	B.Sc: (400) Liccntiaat (=M.Se.) (20) Doktor (=Ph.D.) (100)	Diploma (?) Ph.D. (?)
4	Duration of the curriculum: number of years years (after other degree) until Ph.D.: number of years	Diploma: 5 PhD.: 3	Gtnd.Scicnl.: 4-6 Doctor Scicnt. (=Ph.D.): 4	Cand. Mag.: 3.5 Cand. Scicnt. (=Cand. Mag. + 1.5): 5 Dr.Sc (=Ph.D.): 3	B.Sc. 3 M.Sc. 5 Doktor (=Ph.D.) 3-5	Diploma: 4-5 Ph.D.: 4-6

* ad 1. There arc many differences in "secondary schools" in the European countries: eg. in Germany it is starting at 12 years, in Portugal at 15 years; The number of years with biology and other subjects can vary much more than indicated: indicated is only the situation for pupils going into higher education in biology. In Austria the system of basic/secondary school is currently reformed to more homogenity.

Annex **II.**

THE EUROPEAN COMMUNITIES BIOLOGISTS ASSOCIATION (ECBA):
Aims, Activities and Members

Origin
In 1975, the biologists association of the different countries of the EEC have been federated in the European Communities Biologists Association (E.C.B.A.). Since January 4, 1991 ECBA is registered in Belgium as an a.s.b.l. (association internationale sans buts lucratifs).

Objectives
Presently there are represented in ECBA the national bodies of biologists from Belgium, Denmark, Germany, France, Greece, Ireland, Italy, Luxembourg, Portugal, Spain, The Netherlands and the United Kingdom as full members. The bodies from Austria, Norway and Sweden are associate members and observers from Finland and Switzerland are participating in meetings and other activities. Although all national bodies have different structures, different ideas and although the aims are of a great heterogeneity - ranging from a loose connected federation of biologists (Denmark, Netherlands) to a rigidly organized professional body recognized by state regulation (Italy) - the general objectives of the European Communities Biologists Association were unanimously agreed.

Aims of the European Communities Biologists Association (reviewed by the Council Meeting of ECBA, Sicily 1990).

1. To represent the professional interests of biologists in the European Communities
2. To ensure the professional competence of biologists within the European Communities
3. To provide information on professional matters concerning biologists
4. To promote cooperation between national biologists associations throughout Europe and to facilitate free movement of biologists within the European Communities
5. To promote the exchange of those teaching biology in all classes of educational establishments.
6. To promote the recognition of the essential role of biology in education of the public at all levels of the education system.
7. To advice the EEC and the public in general on biological matters having implications for society.

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