Biologists in European society

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BIOLOGISTS IN EUROPEAN SOCIETY

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REPORT OF THE EUROPEAN COMMUNITIES
BIOLOGISTS ASSOCIATION

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1 INTRODUCTION

Communities have not always been as large and complex as the European Community in the last quarter of the twentieth century. For many centuries people lived as part of a small identifiable community. The ability to travel even short distances was very limited, the communities were small, effectively separate, self-contained towns or villages. People knew each other, had a sense of identity and recognised their individual roles in that community.

The Industrial Revolution, the growth in population, the concentration of people into large towns and cities, the development of transport networks used by large numbers of people, have all rapidly changed the concept of a community. Communities are now much larger and less clearly defined, they can be considered on a regional, national and international basis. Communities are less a collection of individuals and more a collection of groups recognised by their different trades or professions. Rarely does an individual in a particular profession know and appreciate the role of someone in another profession; contact between them, when it occurs, is usually informal and often accidental. People should know what part others play in a community despite, perhaps because of, its complexity.

1.1 Aim of this booklet

In *The Doctor's Dilemma*, G.B. Shaw observed that 'All professions are conspiracies against the laity'. The fact that a distinctive profession of biologist exists is comparatively new and this paper attempts to reduce the possibility of the profession being a conspiracy to confuse the general public.

In Western Europe there are over 50,000 trained professional biologists who are deeply involved in examining problems that affect the whole of society. This booklet aims to give an idea of what biologists are, what they do and what they can and should be doing in the future. The context is essentially European, but the problems and the implications are world wide.

1.2 History of biology

The study of living organisms is as old as man himself. From the first appearance of the human being, his life depended upon plants and animals; his health, protection, food and survival required a knowledge of the forms of life and of the physical environment around him.

From prehistoric times, man has had to distinguish the life forms around him; thus identification and classification of plants and animals provided the start of the classical disciplines of botany and zoology. Information from areas of what we now call medicine and agriculture was built into a framework of knowledge which was handed on to the new generations. The information was descriptive, for precision and experiment were a late phase. It is only in the last few centuries that scientific techniques developed as biology, physics and chemistry grew quickly as experimental subjects. New techniques from the physical sciences and mathematics combined with the study of life in all its manifestations and led

to the concept of 'Biology', a term first used by Lamarck in 1802. Biology is still a relatively new science.

The study of living organisms had a long and important phase when organisms were described and classified as to make an ordered study of the bewildering numbers and kinds of plants, animals and micro-organisms. This classical phase of the history of the subject is still of great importance.

The size, the variety and the complexity of life forms present their own problems. The smallest organisms are beyond the limits of the human eye and even in organisms of this size all the activities of life take place; substances enter from the environment, are built up, broken down, transformed, moved and waste products eliminated in a complicated but ordered way. To study the mechanisms which bring these changes about, techniques and equipment had to be developed: good optical systems, transmission and scanning electron microscopes, high speed centrifuges, manometric, spectrophotometric, chromatographic, radiobiological and electrophoretic equipment. New techniques and equipment allow biologists to isolate, purify and study small particles that make up cells to study the biochemical basis of life. Tremendous advances have been made, but detailed studies have taken place in only a few organisms and there is a very long way to go before we begin to understand what happens in the vast range of organisms and how they interact with each other in time and space.

The first descriptive phase in the development of biology naturally emphasised the diversity of organisms and highly specialised botanists, zoologists and microbiologists concentrated on their own special groups of organisms. Advances in the study of the cell and its parts have shifted the emphasis so as to recognise the unity of the processes of life. An additional vocabulary has been built up and new concepts add a new dimension to an understanding of the diverse organisms which are at the core of biological studies. The role of each organism (including man) in the biosphere is determined by the organism's interactions with all other components of the system.

The two approaches of unity and diversity complement each other, the separate disciplines within the biological sciences are forged together into a new multidisciplinary biology. New discoveries in one of the disciplines of biology can have a profound effect on other disciplines of biology. It is a rapidly changing situation which needs constant reassessment, as the traditional boundaries between the disciplines are constantly changing because of these interactions. The study of any aspect of biology, e.g. food, illustrates some of these relationships (Figure 1).

Interdisciplinary relationships in the biology of food

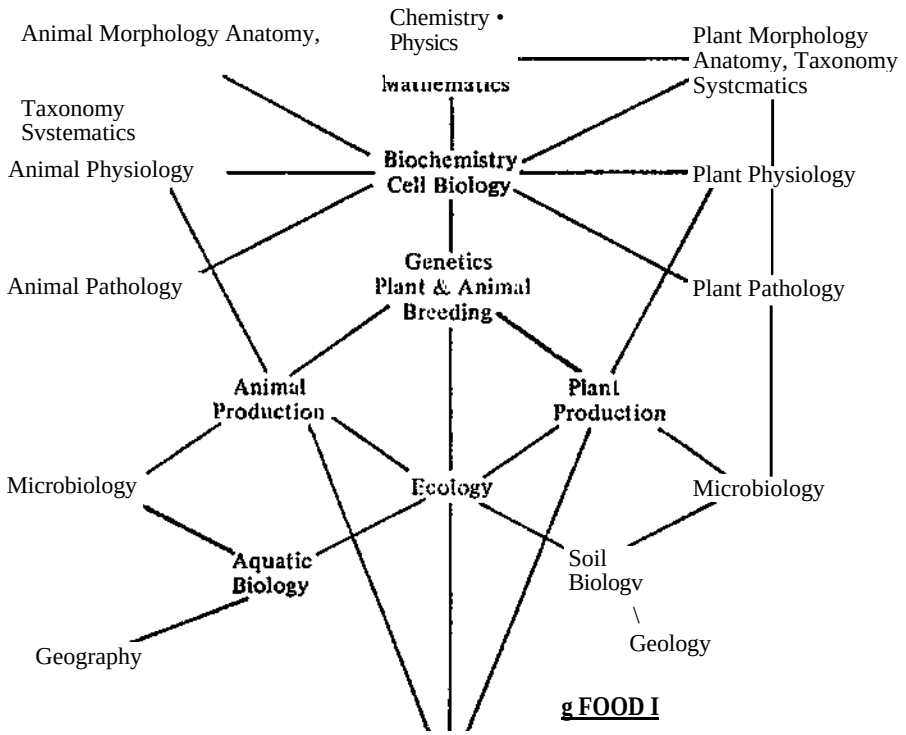

FIGURE 1

1.3 Biologists in society

Above **all,** the modern biologist cannot remain isolated within the constraints of a specialism. It is not enough to break down a complex system to simpler ones because they are more readily investigated. The approach of those who reduce the complex to its individual parts is necessary to identify those parts and to determine how they function and interact; but how the system works as a whole is of special importance in biological investigations. At ail levels of organisation the biologist must have the whole as well as the parts in mind.

As well as being multidisciplinary, with intimate links between its disciplines, biology is also interdisciplinary. The relationships between biology, medical science, veterinary science, agriculture and forestry are longstanding and self evident. The close links between biology and the physical sciences and mathematics have bcome increasingly important and new links between biology and the social sciences are developing. Many of the problems that affect the future of civilisation, including population growth, the production and distribution of food, the well being of the individual, society and the environment are essentially biological and cannot be studied properly without a background of understanding of life in all its forms, how life reacts with the environment and the time scale involved. Biologists must have a voice in determining the order of priority that should be given to questions that need to be answered and the level of support required to investigate them.

2 OCCUPATIONS OF BIOLOGISTS

As the disciplines comprising the field of study of biology have grown, so have the number and the variety of occupations of biologists and they increasingly affect more and more aspects of the life of modern society. Any survey which attempts to classify the range of occupations of biologists must oversimplify the situation, and at best, represent a crude and artifical grouping of a range of work which represents an everchanging continuum.

For simplicity, biologists may be considered as involved in three kinds of occupations: research; teaching; other roles. These activities may be carried out in universities, colleges, schools, industry and the public services. The roles are **not** mutually exclusive and a biologist, even within a single organisation, may, at different times, be undertaking different activities.

Each major category of activity needs to be looked at in more detail in order to help illustrate the sort of work biologists do.

2.1 Biologists in research

The nature of research is often defined as primarily developed towards different aims.

2.1.1 *Pure or fundamental research* includes investigations entirely devoted to the advance of our understanding of life, its forms and its interactions. The research is of a nature which, at the time of the investigation, may be thought not to have foreseeable applications. This is the traditional concept of academic research and the pursuit of knowledge for its own sake. Examples might include: taxonomic investigations of organisms; mechanisms of biological catalysis; energy utilisation in organisms; the physiological action of hormones; animal behaviour.

2.1.2 *Applied research* is research carried out with the specific aim of resolving a question which has become apparent and is recognised to be directly or indirectly important to man. Such as: How can this particular parasite or vector be controlled? Is it possible to increase the productivity of wheat without it impairing the useful disease-resistant properties of the strain? Can more antibiotic be produced by a micro-organism by increasing or changing the nutrients provided to its culture? Will the use of this pesticide constitute an environmental hazard? What is causing this fuel or food to become contaminated, how can it be controlled? Can more effective use be made of indigenous plants and animals to increase food production in the third world?

2.1.3 *Research interactions.* The distinction between pure and applied research is artificial and can be misleading. They are not separate and interact closely often in unpredictable ways. When basic biological processes are better understood it is often possible to translate the results of pure research into tangible benefits to mankind. Fundamental investigations on: the transmission of genetic information; factors governing entry and exit of chemicals through the limiting membranes of living cells; the control and inhibition of the activities of enzymes; energy production and utilisation in living systems; growth and differentiation of cells, tissues, organs and organisms; the physiology of micro-organisms, plants and animals; population density and community structure, are all examples of pure research activities that could produce results which will be directly applicable to the future of mankind by affecting health, or our capacity to sustain the population of the world.

Investigations on genes and plasmids (extra-chromosomal particles of inheritance) are the basis for the breeding of disease-resistant strains of plants. All pure research on cell division, growth and differentiation might have significance in controlling and curing cancer.

On the other hand, applied research on the use of herbicides to control weeds provided a tool for analysing basic studies in photosynthesis.

It would be foolish to assert dogmatically that pure research of a particular kind wili have no application in the future, or that applied research is academically less significant than pure research. It is only in retrospect that such judgements can be made.

Pure and applied research have their place in academic institutions, government research stations and in industry, it is only the relative balance between pure and applied research emphasis that varies in the different laboratories.

2.2 Biologists in teaching

The greater proportion of professional biologists in European countries are engaged in teaching. Biology is taught from the first years of the primary school through to university level. A teacher qualified in a biological discipline who teaches biology to those in the secondary school is a member of the biological profession as well as of the teaching profession. Those professional biologists who teach the young generation have a vital role to play in society.

The approach to teaching biology depends upon the age of those who are taught. From the earliest years, it is important as well as interesting to children thai they should learn more about themselves and other organisms in the world around them. Gradually, as they grow older, they can understand that the human being is one of many hundreds of thousands of species of living forms and that man is one of the species living on the planet earth. They should know that each species has its place and a long history of variation and selection which peculiarly fits it for its niche in the environment.

The young need to be taught how life's processes take place in cells, tissues. organs, and how they arc integrated and controlled in the organism. They should recognise that these processes differ in different organisms and how they are influenced by environmental factors. They should learn that, for survival, the population is important as well as the individual, that population of different organisms form communities or ecosystems where the well-being of one species is affected by others in the community. They need to be particularly aware of man's powerful influence on the communities, populations and individuals of the world and man's responsibilities for the world and space around it.

Many of the ideas that should be taught are complicated but they should be introduced at the appropriate level of understanding of the individual. The details of the substances involved in bringing about the activities of life, and the genetic code require some understanding of the laws of physics, chemistry and mathematics. The responsibilities of mankind towards other species and the environment and the moral issues that must be faced require maturity and concepts from other areas to be assimilated and appreciated. The role of the biology teacher is to provide a sound basis of the understanding of the facts which will enable individuals to make sensible judgements when they are in a position to do so.

Because of the pace of the increase in knowledge and the development of new concepts in biology, teachers of biology who qualified even a short time ago need to be retrained in order to be effective teachers at any level in education.

2.3 Biologists in other roles

Biologists may be using their particular training directly in their work, *sensit striata,* or may be using the advantages of their education in the biological sciences in occupations which are not strictly biological, *sensu lato.*

2.3.1 *Sensu stricto*

Outside the teaching profession, government service organisations are a major employer of biologists. As well as in the health services and general biomedical research, biologists are also employed in many government financed laboratories, including: forestry, agriculture, veterinary science, fisheries, water pollution, pest infestation control, plant pathology, forensic science, safety standards, botanic gardens, zoos, museums and conservation.

There are many industries which employ biologists, e.g. industries concerned with food, beverage:;, pharmaceutical products and other biological materials such as wool, cotton, leather, paper and wood and others which are subject to biological breakdown, e.g. paint. The biologist has a variety of roles in research. development, production, evaluation, advice, quality control, preservation etc. Some indication of the range of work carried out by biologists is given in Appendix A.

2.3.2 *Sensu lato*

A training in any branch of science may be considered to form a sound foundation for a range of employment which involves obtaining, organising and evaluating information. A training in the biological sciences involves certain special features which reflect the special nature of the subject.

A biologist is familiar with dealing with complex situations, is aware that altering one factor changes the balance and stability of a system: that controls are essential; recognises the importance of the whole as well as of its parts; that complete solutions to problems are not always possible; that time and space are significant elements in any investigation. These are important attributes for many jobs in modern society in communication, administration and management.

3 EMPLOYMENT OF BIOLOGISTS IN THE EUROPEAN COMMUNITY

It is difficult at the present time to obtain accurate information about how many biologists are employed, or the fields of their employment. Biologists in the different member countries of the Community are not organised in the same way, they are not in the same stage of development, the method of collection of statistics varies and there have always been difficulties, especially in distinguishing professional chemists who are working on biological problems, and non-medically qualified biologists working in medicine.

It is known that the employment situation has radically altered, even in the last ten years. It is likely that the situation will continue to change, that there

will be increasing demands for particular biology specialists as the demand for other specialists decreases. Although the spectrum of demand alters, the numbers of qualified biologists required has increased, as has the number of qualified biologists who have been trained. It is a paradox that in most EEC countries, there will probably be insufficient jobs available to use these trained people at the right time.

Biology is a diffuse collection of disciplines and individuals. It is the aim of ECBA to provide a firm organisation in which all the disciplines of biology co-operate. It will then be possible to provide an accurate picture of biological employment on a European basis.

4 TRAINING OF BIOLOGISTS

A consequence of the widespread nature of the subject is that there is a high degree of variability when comparing the curriculum content, especially at university level. This diversity has its strength, in that there is a wide element of choice to students who wish to study biology, but it also has its disadvantages. There has traditionally been a flexible attitude which has encouraged individual members of staff to follow in their teaching their own lines of research. Students often have to study many unrelated facets where there has been little attempt at coherence and little regard to vocational relevance. These are now unacceptable attitudes and ECBA is making a conscious effort to examine cunicula to determine guidelines for a central irreducible core which all biologists should study in a flexible structure where students can select to study in depth from a range of specialisms. The future training of biologists must reflect the vocational as well as the academic needs of the society that will employ them.

Biology should be, but is not, taught in the primary and secondary schools to all pupils in Europe. Even where biology is taught it may not be supported by studies in the physical and earth sciences and mathematics. The kind of biology taught is sometimes not the most useful or valuable. This results in different levels of knowledge, understanding and background when a student reaches university level. In turn, this hampers the development, not only of biologists, but also of those who will not become professional biologists, yet will function in other occupations where a biological perspective is important in taking decisions.

The report on a workshop on 'Biological Curricula at University' was published by ECBA in 1976 and some further notes on biological training are included in Appendix B of this paper.

5 FUTURE ROLE FOR BIOLOGISTS IN SOCIETY

The study of biology instills, from a very early stage, experience of dealing with complex and constantly varying situations where it is impossible to have precise control of all the factors that affect a situation. The biologist is aware that, in natural conditions, so many factors operate at the same time that it is usually impossible to test them all in experimental conditions. In these circumstances a biologist must determine what is important and must be experimentally studied, devise experiments to test hypotheses and establish a method of control of the conditions to ensure the validity of the results. The biologist must be sure that the results are equally valid in the natural situation. This method of approach is fundamental in biology.

The biologist has also had emphasised the theme of unity in studying life, much more so than in other disciplines. The biologist is aware of the importance of the whole, even when problems have to be dissected into minor details. The biologist is aware of the inter-relationships of the parts and that simply adding up the parts does not give the entire whole. The biologist is essentially holistic in approach and inquisitive in attitude, recognises that in solving one problem, without considering related aspects, the problem is not being properly tackled. A biologist must accept less than absolute answers and recognises the need for empiricism and value judgements. These characteristics are a natural consequence of the nature of the subject and the training and result in a distinctive and unique approach which could and should make its own contribution to a wide range of occupations both traditional and new, not least in communication, administration and in management.

At present, it is generally true to say that science graduates rarely have special training or experience in the arts of communication and administration. Science graduates usually move into these areas after a period of work in their discipline. There is increasing scope and necessity for biologists to move into non-biological employment. In the new Europe, a commitment to study at least some of the languages of the community by all the countries concerned is of the utmost importance. ECBA is pre-eminently concerned with free exchange amongst biologists and between biologists and other members of society. This can only be done effectively if the language barriers are overcome.

The days when a biologist could be reasonably conversant with all the branches of biology are long past. Yet it is important that the individual biologist should know what is happening in biological specialisms other than their own because of the intimate relationships between the different specialisms.

Biologists must improve communication skills to explain their own work clearly to other biologists: biologists with an overview of large areas of biology must be able to inform all professional biologists about modern developments and how they may affect different biological specialist areas, e.g. in linking pure and applied research. Biologists with a wide biological background need to be

specially skilled in informing non-biologists of the implications of advances in our understanding of life.

There is a particular role for communication between biologists and non-biologists employed in government, departments of health, housing, transport, education, agriculture, fisheries, environment and recreation, in industry as a whole, and with the general public.

There have been mistakes made by governments and by individual industries which have damaged life and the environment. Some disasters might have been avoided if biologists had been involved in the decision making process.

An awareness that biology is important in understanding most of the problems directly related to the future well-being of man will undoubtedly lead to an increasingly significant role for biologists in society. In the broad canvas of medicine, agriculture, forestry, the veterinary sciences and the environment, biologists have already made many contributions. The role of biologists in education should not be confined to teaching from kindergarten to university. In our democratic system, an informed populace can affect the direction in which society develops. Decisions are being made by those who have little biological understanding, yet the decisions often have implications with important biological dimensions. It is therefore vital that the valuable contributions that biologists can make are expressed clearly and are widely and effectively covered by radio, television, cinema and the press.

To ensure that biologists are educated in order to meet the demands of society, internationally discussed and agreed standards are required. On the other hand, society, needs to be well informed of the contribution that biologists can make. Biological phenomena do not recognise national boundaries and biologists cannot afford to concentrate exclusively on their national positions. Biologists must investigate the main problems as an international group. Educational co-operation and exchange on a professional basis is indispensable.

ECBA,founded in 1975, is a young organisation which provides the means for biologists, throughout Europe, to act together as an unified profession in co-operation with other professional organisations in medicine, veterinary sciences, agriculture, pharmacy and chemistry. A unified biology profession is an essential pre-requisite to ordered progress in a rapidly evolving situation. ECBA is the appropriate body for consultations about matters with biological implications that affect Europe.

6 SUMMARY & RECOMMENDATIONS

1. *There are over 50,000 trained biologists in the Community* and it is important that society knows what biologists do and can contribute to life in the technological age.

2. *The profession of biologist is new* although the study of living organisms is as old as man himself.

3. *Biology is a field of study which is making rapid advances.* Approaches in training biologists which emphasise the unity of life and those which recognise the diversity of life forms complement each other.

4. *Biology is both a multidisciplinary and interdisciplinary study*, each discipline interacting and profoundly affecting the others. A biologist must both reduce complex problems so as to study the individual components and keep in mind how the whole functions together.

5. *The major problems that affect the future of civilisation, including population growth, the production and distribution of food, the well-being of the individual, health, society and environment are essentially biological* and cannot be studied properly without a background of understanding of life in all its forms, how living forms react with the environment and the time scale involved.

6. *Biologists must have a voice in determining the order of priority that should be given in attempting to solve problems confronting society.*

7. *Biologists are employed in research, in teaching and in a variety of other roles, both biological and non-biological.*

8. *Pure, applicable and applied research are intimately related.* They represent differences in approach to problems and not differences in kind. *All forms of research mutually interact and are equally valuable.*

9. *The greater proportion of professional biologists in Europe are employed as teachers who have a vital role to play in society.*

10. *One of ECBA's aims is to provide an accurate picture of the employment of biologists in Europe.*

11. *The future training of biologists must reflect the vocational as well as the academic needs of the society that will employ them.*

12. *All children should be taught biology whether they intend to become biologists or not.*

13. *A biological training, besides producing biologists, is an ideal general education conferring particular advantages:* familiarity with complex situations which are not amenable to precise controls; recognition of the need for empirical as well as precise judgement; taking a view of the whole as well as its parts.

14. *Biologists must improve the exchange of information amongst biologists and between biologists and the rest of society via the mass media on a regular basis.*

15. *It is imperative that biologists accept the responsibility for general education, so that the public at large is well informed of the biological consequences of its actions. It is equally essential that those responsible for considering the problems and arriving at decisions should consult professional biologists.*

16. *Biological phenomena do not recognise national boundaries, biologists must look at the main international problems as an international group.*

17. *ECBA provides the means for European biologists to act as a unified profession in co-operation with other professional organisations.*

18. *ECBA is the appropriate body for consultations about matters with biological implications that affect Europe.*

APPENDIX A: Employment of Graduates in **the** Biological Sciences

Notes: Research and teaching posts at all levels are not included. Some of the areas of work might be carried out by graduates in medicine, agriculture, veterinary science, chemistry etc. The situation varies in different countries.

Employing Organisations	Type of Work
Health Services	Molecular Biology Immunology Enzymology Bacteriology Virology Cytology Haematology Medical Genetics Dietetics Neurochemistry Neuropharmacology Reproductive Physiology Drug Metabolism Epidemiology Parasitology Radio biology Cancer Sports Science Public Health Instrument Technology Clinical Biochemistry Clinical Microbiology
Pharmaceutical Industry	Animal Physiology Animal Pharmacology Clinical Pharmacology Biochemical Pharmacology Drug Metabolism Drug Production Drug Toxicology Bioassay Quality Control Sales and Marketing
Food, Brewing, Agrochemical Industries	Animal Biochemistry & Physiology Animal Pathology Animal and Plant Breeding Meat and Dairy Products Ruminant Microbiology Food Microbiology

Employing Organisations	**Type of Work**
Food, Brewing, Agrochemical Industries	Fermentation Technology Brewing Glasshouse Crops Tropical Plant Biology Plant and Crop Physiology Soil Science Biodeterioration and Biodegradation Plant Pathology Crop Protection Pest Control, Virology Bacteriology Protozoology Nematology Entomology Helminthology Weed Biology Agrochemical Production Testing Toxicology Petroleum Products Fisheries Research Quality Control Sales Marketing Administration and Management
Government and Local Authorities, Water Industry	Terrestrial Ecology Aquatic Ecology Forestry Hydrology Conservation Pollution Environmental Monitoring Urban and Rural Planning Sewage Treatment Landscape Architecture Amenity and Recreation Biology Information Science Scientific Publishing Museum Curators

APPENDIX B: Notes on the **Biological Curriculum**

See also *Biology Curricula at Universities*, ECBA, Amsterdam, 1976

Essential Background to Biological Studies

All children from their first days in school should be taught biology and this should be continued into the secondary school stage irrespective of what they will do in adult life.

In schools biology should be taught in such a way that it provides a comprehensive background for those who will not continue into tertiary education as a general education to equip them to understand the technological society- For those who proceed to the tertiary education level, biology must provide a background for those who will work in other subject areas of the sciences, engineering, the arts, humanities and will eventually take up their own profession and for those who will work as professional biologists. For the latter, ECBA (1976) has already clearly stated that a knowledge of physics, chemistry, mathematics and some study of the earth sciences are an essential preparation for the study of biology in depth. The school curriculum needs to be organised so that this combination of study is possible and encouraged.

The Biological Curriculum

Unity and Diversity. A general background to the nature of those processes that characterise life should be considered and the unity of these activities should be stressed: that life involves cyclic processes governing the maintenance of raw materials and energy and how these involve interactions between all living organisms; that life depends upon the maintenance of common coding systems passed on from generation to generation providing the basis for stability and at the same time the raw material of variation which is subjected to selection pressures over time. In addition, some idea of the wide range of life forms should be taught in order that the position of man should be appreciated in the biological context of time. In dealing with different life forms, whether a bacterium, a plant or man, emphasis should be placed on how the processes of life are carried out by the same basic activities, but with a great variety of modifications associated with the complexity, habitat and history of the species over the long time scale of evolution.

Form and Functions. It is important to understand that the relationship between structure and function of different life forms is the key to the ability of the organism to survive. Each form has its particular strategy related to the environment and a basic idea of form and function of protists, plants and the much wider range of animal groups is needed to place different organisms in a proper context.

Populations. The importance of collections of individuals of a species forming populations, inheritance within populations, and behaviour patterns, are aspects of human and other populations which can provide the basis of understanding of

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