Issues-Based Framework for Bio 101

an excerpt from the

REPORT OF THE

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COALITION FOR EDUCATION IN THE LIFE SCIENCES

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NATIONAL LIFE SCIENCE EDUCATION CONFERENCE II
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INTRODUCTION

Inherent in the recommendations urged in this report is the overall belief that science, especially the life sciences, must be part of a core of knowledge for all Americans if they are to participate fully in our society. There is much about the natural world that we do not know, yet much that we need to know. We live in a complex world, besieged by complex problems. Our ability to understand, and appropriately respond to, the issues of the day, relies on the supposition that we, as a people, are educated regarding these issues. All too often that is not the case. The situation is urgent, and growing worse with each passing day.

Participants at the second meeting of the Coalition for Education in the Life Sciences (CELS II) devised the following Guiding Principles as a way to correct the current state of affairs, and move us toward the educated state necessary to our survival as a world and as a people.

GUIDING PRINCIPLES

The recommendations below are not a placebo, nor are they a coat of paint thrown over a badly dilapidated educational structure. They are the ingredients vital to a necessary overhaul of our entire system of science education. They represent, in short, our best hope to provide a means to achieve literacy in the life sciences in this country.

1. Science should form a core consisting of 20 percent of the undergraduate curricula. Since this must build upon the education students receive in the K-12 years, we applaud all efforts to develop and implement hands-on, inquiry-driven science education for these students.

2. To become educated citizens, all college and university students need no less than a year's study of the biological sciences, including an inquiry-driven lab and/or field experience relating to the critical issues of our times.

3. Given this need, new thinking must occur, and new resources must be developed, including endowed chairs, adequate provisions for support staff, and grants for curriculum development at the college and university level.

4. Mechanisms must be developed to foster closer interactions between teachers/science educators, researchers, and college/university faculty to maintain a close collaboration in this endeavor.

The urgency of these goals must be understood by our university administrators and faculty, scientists, parents, and students alike. Further, they must be taken to heart by legislators, business leaders, and other decisionmakers, including the future electorate, who must have the ability to deal with complex issues and make informed decisions.

CELS, and the many scientific societies it represents, will work to advocate the policy changes necessary to implement these recommendations. Further, it will work to facilitate communication between the educational forums of the National Academy of Sciences and other groups, federal and private funding agencies, and through the members of our professional societies, who are active participants in research, education, and industry.

Inherent to science and science education is the perspective through which science must be understood and conducted. Science is the sum of the efforts to understand the natural world in a systematic, empirical manner. An experimental approach is based on observations to construct models of phenomena, events, and structures that allow prediction. Science values the power of theory for explaining and predicting. Science is dynamic and everchanging. Science is problem-solving. It is similar to detective work, involving investigation, and it is fun. The underlying assumption is that there are patterns to be discovered. Science is a community effort and is self-correcting. Success of science depends upon integrity, honesty, openness, logical thought, care and precision. It is driven by curiosity and skepticism. The scientific study of life involves responsible investigation of all life forms.

ISSUES

Life science issues cry out from the headlines of newspapers daily. These issues affect much of what we do, and the very quality of our lives. How they are resolved will determine our future and survival as a world and as a people. Comprehension of and solutions to these issues are inherently based through the understanding of the life sciences.

Thus, systemic reform in life sciences education begins with an analysis of what knowledge students must possess to deal with the problems confronting us, and to be educated about the world around and within us. A consensus on what it is students must know forms the foundation for creating a more effective curriculum and methods of delivery.

Representatives from thirty life science societies present at CELS II selected six over-arching issues that help to define life science and its relationship to society as a whole. They assert that, at a minimum, these issues, listed below, must be studied in order to produce educated and contributing members of society. These issues do not represent a comprehensive list, but are indicative of the scope and type of concepts and concerns that need to be covered in undergraduate life science education.

(It should be noted that use of the words "we" and "our" in the issues described below encompass not only humans, but all forms of plant, animal, and microbial life.)

Wellness

1. Balance/homeostasis. Our bodies are constructed with interrelated systems that respond to change and maintain balance.

2. Nutrition/energy. Proper nutrition provides the building blocks and sources of energy to maintain the balance of our systems.

3. Growth and development. We are designed to live, grow, reproduce, and die.

4. Disease/pathogenicity. We live in competition with a number of chemicals, viruses, microbes, and other organisms that can disrupt our balance in different ways.

5. Protection/immunity. We have evolved defenses against pathogens, and these defenses can be strengthened by manipulation.

6. Community health. Our social institutions must be designed to protect the health of individuals, providing clean water, adequate nutrition, and access to medical services.

Shaping/Reshaping Life

1. Inheritance (Mendelian and non-Mendelian). Living organisms are governed by a set of inherited instructions that are passed on from one generation to the next.

2. Information read-out (normal gene expression, genetics of development). Information encoded in the structure of DNA is expressed by the cell as proteins which shape the traits of the cell and the organism. Expression of traits is influenced by environment.

3. Variability/evolution (diversity). All organisms share a common genetic origin. Changes in genetic information occur and may result in changes in traits that affect the interaction of the individual with the environment.

4. Sexual reproduction. Mixing the encoded information (DNA) through the process of sexual reproduction has resulted in an evolving diversity of organisms.

5. Gene manipulation. Humans now have the ability to alter this information and quickly change specific attributes of living organisms.

Overpopulation

1. Carrying capacity/exponential growth. The human species has continued to grow exponentially and is challenging the resources of the earth.

2. Primary productivity. Humans are dependent upon the primary productivity of other species.

3. Limiting factors. There are physical, chemical, and biotic factors that limit primary productivity.

4. Interconnectedness. Due to the interconnectedness of the living and non-living components of the earth, population growth impacts every aspect of the earth's systems.

5. Reproductive biology. Understanding of fundamental concepts about reproductive biology at organismal and population levels are essential to understanding the consequences of overpopulation.

6. Cultural factors. Powerful determinants in the rate of human reproduction are socioeconomic status, religion, education, and the status of women.

Resource Utilization

1. Resources. Important resources for life on earth include food, water, air, space to live, shelter; humans also demand energy.

2. Renewable resources. Biological systems have the capacity to renew some of the resources we use. Humans must be careful to maintain that capacity.

3. Non-renewable resources. Rapid utilization of non-renewable resources reduces their availability for future generations. We must investigate ways to reduce the rate of such utilization and consider the use of alternate resources.

4. Interconnectedness. Tampering with certain resources (e.g., soil, air, water) affects the availability of other resources (e.g., plants).

Alteration of Natural Systems

1. Ecosystems. The living world is a closed system that has cycles of energy transfer and matter flow.

2. Biodiversity. The world's biodiversity is rapidly disappearing. Biodiversity is the variety of life at all levels of biology. Not only does biodiversity enhance the quality of our lives aesthetically and practically, it is part of our life-support system.

3. Changes have consequences (interactions and interdependence). Change is a part of natural systems. Physical and biological changes in the world affect each other. Human activities have increased the rate of change with sometimes devastating effects on natural systems.

4. Adaptation/extinction. These processes are the result of biological evolution in an everchanging environment as evidenced by history.

5. Humans as part of the system. Humans, as organisms, are intimately linked with the natural world. Humans have the ability to impact natural systems beyond their immediate environment in time and space. However, ultimately there are consequences for living on limited resources.

Functional/Dysfunctional Behavior (Inter-organismal interaction)

1. Individuals in relation to their environment. Organisms detect, respond, and compete for resources in their physical and biological environment.

2. Individuals in relation to other species. Organisms interact with other organisms in fundamental ways. Types of relationships include competition, predation, and mutualism.

3. Individuals in relation to conspecifics. Behavior often occurs in a social context. Types of social behavior include communication, competition, and cooperation.

4. Determinants of behavior. Behavior can be understood at different levels. There are chemical, neural, morphogenetic, and cultural determinants of behavior. Behavior has both learned and innate components which have evolved over generations.

5. Dysfunctional behaviors (substance abuse, social conflict). This behavior often occurs under stress.