An Integrated Course in Agricultural Biology

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Abstract

The continued success of agricultural industry depends on a supply of qualified professionals serving a rapidly changing industry. Higher education must structure curricula to meet evolving needs. Lack of development of problem solving skills creates a gap between basic science and real world problems. An integrated curriculum providing a link between basic biology and food systems courses should strengthen and expand the graduate's analytical, problem recognition and problem solving skills. We describe an introductory agricultural curriculum that integrates basic biology and some chemistry with an introduction to agricultural production, including crops, livestock, and associated biotechnology.

Introduction

Agriculture, as the foundation of the nation's food production system, remains a critical component of American economy and society. The continued success of this vital industry will depend on an adequate supply of qualified professionals to serve a rapidly changing industry. Growth in knowledge, exploding technologies, increased awareness of the impact of production practices on the environment, an ever growing population, and serious economic considerations combine to require new types of professionals to serve this diverse industry. Higher education faces a major challenge in structuring curricula to meet these evolving needs.

Our food production system depends on practical applications of basic knowledge. Effective professionals must blend practice with theory in diverse problem identification/problem solving situations. Simple mastery of a "recipe book of solutions" is inadequate. The educational process must prepare and require graduates to build from basic concepts and sciences, to recognize novel problems, and to seek logical solutions for unique situations.

During the past several years, we have increasingly sensed that our students have not developed adequate problem identifying/solving skills. A spring, 1994 nationwide survey of academic deans of agriculture and heads of departments of agronomy suggests that this issue is not unique to our institution (Chapman and Ferguson, 1996). Graduates of many agricultural curricula do not see the essential link between science and real world problems in today's agriculture. This reflects a weakness in problem solving capabilities. A curriculum that provides a strong link between basic biology and courses in food systems curricula should strengthen and expand the graduate's analytical, problem recognition/problem solving skills.

Concern over integration of subject matter is not new. The Carnegie Foundation for the Advancement of Teaching sponsored the most recent comprehensive study summarized and interpreted in "College, The Undergraduate Experience in America" (Boyer, 1987). This in depth study included analysis of certain aspects of integrated educational elements, but the effort centered on integration of general education requirements and did not address issues of integrating sciences with other disciplines. Nonetheless, the findings and conclusions reflect issues that motivate this study: shared academic goals and education that help students see connections and broadens their perspective.

After an extensive literature review, Berlin (1991) found few documents related to integrating science and mathematics in teaching and learning in post-secondary education. A relevant example is the work of Garafalo and LoPresti (1986) who discuss an integrated college freshman natural science curriculum designed for chemistry majors. They state that traditional curricula yield students with a highly fragmented view of nature. An integrated curriculum can yield students with the same competence but with an improved ability to see the interrelationships between diverse disciplines. Reinforcement of unifying themes and qualitative presentations of concepts preceding quantitative ones may lead to development of critical thinking skills and true conceptual understanding.

Pinsky and Speed (1978) developed an Integrated Science Program using mathematics as the foundation for highly quantitative courses. Their philosophical concept relies on using an extensive common base to the scientific disciplines. The exercise of intellect, analysis, innovation, and the organization of knowledge are more effective if we emphasize the common base rather than the conventions and techniques unique to each discipline. In addition, the undergraduate years are when students should learn in breadth and depth the full realm of science. More recently, Leroy Hood (Roberts, 1994) is forging a venture which combines technology development with cutting edge biology. This common goal ties together a variety of faculty

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including biologists, physicists, computer scientists, and engineers.

This paper describes an introductory agricultural curriculum that integrates basic biology and, to a lesser degree, chemistry, with an introduction to agricultural production, including crops, livestock, and associated biotechnology. This curriculum will yield students with enhanced analytical skills and problem solving ability.

Specific curricular objectives

The five specific objectives of this curriculum are: to present an integrated, coherent organization of content relevant to the entire food system including production agriculture and the plant and animal sciences; to integrate introductory biology, and the introductory agricultural sequence in plant and animal science; to emphasize critical thinking and develop problem solving skills; to promote oral and written communications skills; and to involve faculties with diverse interests and backgrounds.

This integrated, comprehensive effort represents a novel approach to resolving an increasingly recognized educational deficiency: lack of integration of subject matter and development of problem solving capabilities. It represents a new approach in teaching traditional agricultural sciences and the basic science required for today's agricultural technology.

An example of comprehensive integration

The curriculum introduction includes world food and human dietary needs and the diverse ways in which human dietary needs are satisfied. After two or three class meetings, attention turns to several diverse dietary examples, from something as simple as a peanut butter and jelly sandwich with a glass of milk or prepared convenience foods to the sophisticated "meals in a tube" of the space age. The focus will be the basic dependency on plant life as the fundamental link to convert solar energy through photosynthesis to food.

When the ingredients of a meal of peanut butter and jelly sandwich with a glass of milk are considered, some of the subject area topics that become evident are:

Biodiversity: at least four plant types (wheat, peanut, sugarcane, and fruit tree or vine), one fungus (baker's yeast), one animal (dairy cows).

Anatomy, Growth and Development: of plants, fungi, and animals.

Fermentation: chemistry of bread-baking

Taste: human senses and nervous system

Soil types: varying culture conditions for the above organisms

Plant Physiology: ripening of fruit for jelly

Genetics: of all the above organisms

Biochemistry: the nutrients in food (protein, fat, carbohydrates, sugars, vitamins, fiber)

Instructional units covering aspects of the above topical areas could be developed around the theme of a peanut butter and jelly sandwich. Such integration will help students see relationships, broaden their perspective, and develop problem solving skills.

The curriculum plan

Tables 1, 2, and 3 represent topics and concepts covered and instructional organization of the integrated program. These tables are designed to address the same program from different viewpoints. Table 1 illustrates topics generally covered in introductory biology and the introductory plant and animal science courses. As evident in Table 1, subject matter in biology is repeated in plant and animal sciences. Although repetition is important in learning, we feel that the integrated approach will increase student interest and motivation by showing the relevance of basic science in agricultural biology and the direct relationship between the applications in agriculture and the subject matter of biological science. Biology subject matter content will compare in depth to the content in typical introductory biology courses which include much more information about cellular biology than is typically found in introductory agricultural science courses. The integrated course must stress this vital area. The organization of material in this integrated course is intended to help students see the relevance of the chemistry and physiology of cellular processes. The industry of agriculture and its relationship to the world can be used to address the topics covered under the broad heading of community in biology. Production of agricultural products is a direct application of the growth of living organisms.

Table 2 illustrates the major concepts that will be stressed throughout the course. These concepts will not be presented as instructional units, but will be referred to at any point when a given concept is relevant. The stress will be on the interrelationship of material at the concept level.

Table 3 presents a broad outline of our proposed syllabus. Topics (Table 1) and concepts (Table 2) will be covered within the instructional units shown in Table 3. Material from biology will be used to develop important agricultural concepts within instructional units. The order in

which topics are covered relates to the underlying theme of the importance of agriculture to human needs, beginning with discussion of specific human needs and the role that agriculture plays to meet these needs. Diversity of life forms is included next and leads into units covering specific aspects of agricultural biology.

Examples of hands-on exercises and experiments which could be included as part of each instructional unit are shown in Table 4. Land-grant and other agriculture universities are in a unique position to use some of these exercises for the benefit of students in agricultural sciences and non-science majors. Teams of students could work together to complete the exercises and solve the problems. This approach allows students to participate in real-life situations while learning basic science and its applications. These projects offer an alternative approach to learning and its assessment based on interaction with others in the group. Performance evaluation of such projects would be similar to job evaluation in the market-place.

Conclusion

Students completing this integrated freshman course will receive credit for introductory biology and introductory plant and animal science courses. This integrated approach will require students and faculty to focus on the importance of advanced courses in both the basic sciences and in applications within food systems curricula. This introductory program will establish a foundation of integrating science and technology. By incorporating the basic biology traditionally covered in biological sciences into introductory plant and animal science agricultural science courses, two accomplishments result: a better understanding of the application of biological principles to agricultural systems and the relevance of basic biology to applied agricultural science becomes obvious.

References

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Table 1. Topics covered in introductory biological and agricultural science courses.

Biological Sciences	Agricultural Sciences
Community Diversity of life Ecology Environment Pollution	**Relationship of Agriculture to the World** Energy and crop production Food, needs, and population Environment Pollution
Populations Behavior Ecosystems Endangered species Genetics	**Industry of Agriculture** Food crops, plant derivatives Fiber, forest and ornamentals Meat and wool Dairy and poultry products
Organisms Inheritance Animal growth and development Regulation in animals Human growth and reproduction Regulation in plants Plant growth and development Nutrition and transport in plants	**Animal and Plant Biology** **Genetics** Anatomy Physiology Growth and development Reproduction Nutrition
Cells Chemistry Photosynthesis Respiration Molecules and genes Sex and cell division Development of cells	