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ABSTRACT

Summaries of the recommendations made by action committees established by the Panel on Pre-Professional Training in the Agricultural Sciences are made under the headings "Biological Subject Matter," "Mathematics," and "Physics." The action committees in Animal Sciences, Bioengineering, Food Sciences, Natural Resources, Plant and Soil Sciences, and Social Sciences based their recommendations on the undergraduate requirements for professionals who will be working in the 1980's. These recommendations are synthesized by the panel, which presents an outline of a typical science curriculum for agriculture majors, and discusses the trends in undergraduate agricultural education. Panel and committee members are listed. (AL)

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REPORT OF THE PANEL ON PRE-PROFESSIONAL TRAINING IN THE AGRICULTURAL SCIENCES[1]

INTRODUCTION

In 1965 the Commission on Undergraduate Education in the Biological Sciences (CUEBS) established a **Panel on Pre-Professional Training in the Agricultural Sciences** to consider the following questions:

(1) What preparation in basic biology, physical sciences and mathematics is desirable for students planning careers in the agricultural sciences?

(2) To what extent can agricultural curricula include the same biology core program taken by other biological science majors?

The panel early recognized that it would be an Herculean task to evaluate adequately all the implications involved in the questions posed, especially when students in such divergent areas (e.g., forestry, wildlife, food science, agricultural engineering, pre-veterinary medicine) were to be considered. In an effort to obtain the broadest thinking possible, six action committees composed of scientists from universities throughout the country were created in cooperation with the Commission on Education in Agriculture and Natural Resources (CEANAR). Each action committee considered one of the following areas: animal sciences, plant and soil sciences; natural resources, food sciences, bioengineering, social sciences; and each was charged with the responsibility for studying and recommending desirable preparation in the biological sciences and cognate disciplines for undergraduates majoring in the committee's area of specialization. The committees were asked to think in terms of requirements for students who will be professional scientists and agricultural production workers in the 1980's. The complete reports of the Action Committees will be published at a later date, but a summary is given below.

SUMMARY OF ACTION COMMITTEE RECOMMENDATIONS

One basic premise recurs throughout the reports: All agricultural students should take the same courses that other science students take. There should be no "special" courses in mathematics, physics, and chemistry for agricultural students.

Biological Subject Matter

Integration of the study of plants, animals and microorganisms in an introductory sequence in biology was a strong recommendation of all committees. Opinions differed, however, on whether this sequence should begin in the freshman or sophomore year. Those who recommended delaying it until the sophomore year did so in order to allow structuring of the course at a higher level, following the study of introductory chemistry and mathematics. In this case, physics and elements of biochemistry would be either prerequisite or corequisite.

Most committees assumed that entering students would have had BSCS biology or its equivalent in high school.

While only two committees (Social Sciences and Natural Resources) specifically suggested emphasis on economic plants and animals in the introductory sequence, several others recommended that higher organisms be used when possible in the illustration of basic biological principles.

[1] The term agricultural sciences is used in this report to encompass all areas of agriculture and related sciences, including offerings in colleges, schools and departments of agriculture, forestry, conservation and natural resources.

At least two different approaches to teaching the introductory biology sequence were recommended. In one, instruction would be organized on the basis of levels of biological organization (e.g., molecular, cellular, tissue-organ, organism, population and community) and proceed in that order. (The Plant and Soil Science Committee recommended that instruction begin and end with the organism, an entity with which the student would be more familiar.)

The second approach would be a somewhat traditional—albeit integrated—arrangement beginning with a study of matter and the least complex organisms. Instruction would then proceed to cell structure and function, growth and development, physiology, reproduction, genetics and evolution, behavior and the nervous system, taxonomy, etc., with some recognition of the features which distinguish plants from animals.

The choice of approach recommended was somewhat related to the year during which the biology sequence would be started, with the Food Science and Bioengineering Committees recommending that the "levels" approach be started in the sophomore year.

There was very little general agreement on the most appropriate theme for the introductory sequence or, indeed, whether there should be a theme. At least two committees (Social Sciences and Bioengineering) preferred an ecological theme, but several others placed more emphasis on unity in biology.

The Social Sciences Committee's recommendation limited biology instruction to a single first year course, except for farm management and agri-business majors. It recommended that ecology, behavior and genetics be stressed in the first year course and that more emphasis be placed at the organism, population and community levels than at the molecular and cellular levels. This committee would use the laboratory only when it was the most efficient way of teaching concepts and principles, rather than using it simply for the teaching of techniques.

The committees recognized and generally endorsed the idea that the increasingly quantitative and analytical nature of biology should be reflected in the undergraduate courses. This appealed especially to the Bioengineering Committee. Several committees, however, cautioned against treatment of biological topics exclusively in abstract physical-chemical terms.

Mathematics

Strong support for mathematics came from all committees. It was recognized that most high schools in the future would provide pre-calculus training; thus the first required college mathematics could be a year of calculus. College students with inadequate mathematical backgrounds might be required to take pre-calculus courses without curricular credit. The increasing need for skills in statistics and data processing was recognized. Some committees recommended a second full year of mathematics, including mathematical analysis, linear algebra and probability.

Chemistry

All committees recognized the need for organic chemistry and all except the Social Sciences Committee recommended biochemistry. In some cases, physical chemistry was recommended. Uniformly there was dissatisfaction with the present omission or de-emphasis of the chemistry of organic compounds in most current introductory chemistry courses. The committees also stressed the need for a quantitative physical approach rather than a descriptive approach to the first year course in chemistry.

Physics

The need for college level courses in physics was acknowledged by all but the Social Sciences Committee (which concluded that a good high school physics course was sufficient). The committees generally recommended one year of college physics. Some suggested that a course in biophysics, taught by a biologically oriented department, should be offered. The committees placed less emphasis on physics than on chemistry, but there was overlap in the recommendations for the subject matter areas of physics and physical chemistry.

PANEL RECOMMENDATIONS

Students in all areas of agriculture should, as a minimum, take a basic integrated general biology sequence containing concepts of organismal biology, environmental biology and molecular-cellular biology. The treatment should be rigorous and the program should follow adequate preparation in chemistry, mathematics and physics.

Upper division courses important to the field of emphasis (e.g., animal science, food science) should be built upon the basic biology sequence. Courses such as biochemistry, ecology, genetics, microbiology, pathology, nutrition and physiology would be appropriate, depending upon the area of student specialization and the level of attainment sought.

Those students whose career interests are indefinite at the outset of their college career might be offered a course in applied biology to help them decide upon their goals. (Such a course might also be of interest to liberal arts students.) The course might consider such topics as an overview of the ecosystem, the relation of animals and plants to the culture of man, world food problems, etc. The course would not be prerequisite to courses in the general biology sequence.

If appropriate biology "core" curricula are developed at various institutions, all agriculture students should participate. The core should be flexible enough so that students in agricultural economics, rural sociology or agri-business might leave it at the end of the first year with a good basic appreciation of biological principles. However, all other agriculture students should take the full core, usually two to five semesters in length, with concomitant chemistry, physics and mathematics.

A typical curriculum in natural science for students planning careers in any area of agriculture other than agricultural economics, rural sociology or agri-business might assume the following form:

First Year: Chemistry—General Chemistry, with emphasis on carbon compounds. Mathematics — Introductory calculus, linear algebra (See courses 1 and 3, CUPM report).[2] Physics—General physics.

Second Year: Biology[3] — Organismal biology,[a] environmental biology,[b] and cellular-molecular biology.[c] Chemistry — Organic chemistry plus physical chemistry or biochemistry. Mathematics — Probability (See course 2p, CUPM report).[4] Physics — As required by field of emphasis.

Third Year: Biology — Selected courses in areas basic to field of interest (e.g., biochemistry, ecology, genetics, microbiology, nutrition, pathology, physiology).

Fourth Year: Biology — Specialized biology, systems biology and population biology.

The above recommendations are based upon the following premises:

A) The undergraduate curriculum should allow for emphasis in three major areas: (1) graduate study, which embodies strong requirements in the basic sciences; (2) work of a technological nature, which may require some graduate work to increase the depth of knowledge; (3) work in the "management" areas, which may require a fifth year of study.

B) At the advanced levels, the undergraduate curriculum should allow for differences in depth and emphasis. The food sciences, for example, may need concentrated work in molecular and cellular biology; natural resources may need additional emphasis upon population and community biology; etc.

C) The undergraduate curriculum should offer flexibility to students. Many students change their majors prior to graduation. Concentration on basic science and mathematics courses during the initial years will enable students to shift career objectives without serious loss of time.

2 A General Curriculum in Mathematics for Colleges, 1965, Committee on the Undergraduate Program in Mathematics (CUPM), P. O. Box 1024, Berkeley, California 94701, p. 76.

3 Following are examples of topics that would be included in such courses. No sequential order is implied by order of listing.

a) Structural and functional organization of higher plants and animals; physiology, growth and differentiation, morphology, organization of higher organisms; contemporary topics such as biological clocks, photoinduction of flowering, neural secretions, behavior, and self-recognition mechanics.

b) Concepts of the ecosystem, including energy exchange, productivity, physical limiting factors (light, temperature, water, and radiation) and biological limiting factors; structure and dynamics of populations and communities; fresh water, marine and terrestrial habitats; ecology and human welfare, including agriculture, natural resources and public health.

c) The chemical and physical properties of cells, enzymes and chemical reactions, cellular differentiation, stimuli and response characteristics, sexual and asexual reproduction, and mutations in genetic apparatus and DNA.

4 A General Curriculum in Mathematics for Colleges, 1965. Ibid.

THE FUTURE OF UNDERGRADUATE EDUCATION IN THE AGRICULTURAL SCIENCES

Education in agricultural sciences is currently offered at a number of land grant and non-land grant colleges and universities. Typically, land grant schools have a large proportion of their budgets devoted to research and extension activities. In contrast, non-land grant schools tend to emphasize teaching and commonly devote only a small proportion of their budgets to research. Further, their teaching is often heavily concentrated at the undergraduate level, whereas, land grant schools also educate large numbers of students at the graduate level.

The pattern of research emphasis in agricultural schools is changing. Private and governmental research centers are conducting an increasing proportion of the applied research that historically has been associated with agricultural experiment stations. In turn, agricultural experiment stations are giving increased emphasis to basic research.

The implications of these developments to future undergraduate training are still not entirely clear. It is probable, however, that undergraduate curricula will be increasingly torn between two masters. Research groups will be highly concerned with devising programs which prepare students for graduate training. Other groups (e.g., extension personnel, forest land managers, agri-business spokesmen) will emphasize the need for preparing students to join the agricultural complex at the B.S. or M.S. degree level.

Improving the image and quality of the terminal program, while at the same time providing a meaningful Ph.D. program, will pose a real challenge for agricultural schools. The solution to this dilemma will vary from school to school; some universities may choose to accept only those students believed capable of Ph.D. level study, while other schools may prefer to educate only the terminal students. Most agricultural schools, however, will probably continue to serve both roles. Some of the needs now being met by four year programs may be served by two year programs in the future.

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