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Problems in agriculture in ten or twenty years will be dramatically different from present ones. The solutions to these problems will require the development of new agricultural or agriculturally related professions such as ecological engineering, space biology, marine agriculture, systems agriculture and industrial agriculture. Dealing with these problems will require an interdisciplinary approach with a more intensive study of basic biological, physical and mathematical sciences. The importance of social sciences and the liberal arts curriculum is acknowledged. A detailed recommended program for plant and soil science majors is presented. The report outlines areas of subject matter concentration in terms of lower division and upper division courses. The proposal is for a four-year college curriculum. (BC)

Report of the

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FOREWARD

In 1965 the Commission on Undergraduate Education in the Biological Sciences (CUEBS) established a Panel on Preprofessional Training in the Agricultural Sciences (PPTAS) 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, preveterinary 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 following report is from one of the action committees. The ideas expressed in the report are those of the action committee members and not necessarily those of either of the sponsoring Commissions. The PPTAS position paper itself is available as CUEBS Publication No. 17.

Martin W. Schein
Director, CUEBS

INTRODUCTION

It is visualized that the problems in agriculture ten or twenty years hence will in some respects be dramatically different. In other respects the problems will differ only in direction, breadth or depth. Several examples of prospective problems and of revisions of existing problems are listed below. The list is not intended to be complete or exhaustive. Other, and perhaps better, examples could be cited.

1) The exploitation of new resources

The exploitation of new resources will be essential to meet the growing needs of a hungry world. Conceivably, this would include utilization and development of arid-region, sub-polar, tropical, marine and space resources.

2) The control and modification of ecosystems

This problem involves alteration of the environment by physical, chemical and other means from a sub-optimal to an optimal condition for plant growth. It is probable that plant protection through the control of pests by biological and chemical means, the control of salinity, the control of atmospheric composition, the control of water by irrigation, the control of soil fertility by fertilization and the control of insolation by planting methods will be included.

3) The securing of plants which make maximum use of the environment.

There are limitations on efficient modification of environments which can be overcome by modifying the plant. Genetic potentials will be exploited in securing plants that are more tolerant to environmental extremes, that make maximum use of the typical environment and that are related to other plants in a manner permitting multiple land use.

4) The control of plant growth, flowering, fruiting and senescence

There will be an extension of existing empirical methods of regulating plant growth by applied chemicals (hormones, herbicides, fungicides, growth depressants, etc.) as basic knowledge regarding the physiology and biochemistry of their action becomes available. In addition, basic work on the biochemical role of nutrient elements will lead to improved fertility practices. In both cases, molecular biology will be called upon for the fundamentals of the regulatory processes directed by the genome and modified by chemicals and nutritional practice.

5) The programming of agricultural production and biological systems

With the advent of computer technology it becomes possible to program cultural practices in agriculture to secure maximum utilization of any environmental variable (early spring rains, late frost, low soil moisture reserves, etc.)

6) The development of agriculture and agri-business in foreign lands

The increasing involvement of the United States in the development of resources in foreign countries will demand an increasingly broad comprehension of fundamentals.

The solution of problems such as these will probably require the development of new agricultural or agriculturally-related professions. A few potential agricultural professions are cited below:

Ecological Engineering - the study and management of natural and disturbed ecosystems

Space Biology - the development of enclosed or semi-enclosed microcosms and exobiology.

Marine Agriculture - the management and utilization of marine plants and soils.

Systems Agriculture - the utilization of theoretical models of plant communities.

Industrial Agriculture - the development and utilization of new techniques for the production of food and fiber.

It is likely that the solution of many agricultural problems of the future will require an interdisciplinary approach. Consequently, the existing barriers between agricultural disciplines should be reduced or eliminated. But this is not enough. Heretofore, agriculturalists have focused their attention on problems of specific agricultural interest. As a result, opportunities to contribute to the political, cultural and scientific progress of the nation and of the world have been overlooked. In the years ahead, the horizons of agriculture should be expanded to include areas that, by tradition, are not agricultural in nature but to which the agriculturalist can make significant contributions.

In view of this and in order to remain an integral and respected part of the university community, schools of agriculture must improve the quality of their undergraduate education. This improvement should be primarily in a more intensive study of the basic biological, physical and mathematical sciences.

It is believed that all agricultural students, with the possible exception of those in the social sciences and education, should have the same basic program in the first two years of their college career. This program should emphasize the aforementioned sciences and the liberal arts and should not include (excepting one or two courses noted later) professional courses in agriculture. Insofar as possible, it should include no special courses for agricultural students (i.e., agricultural students should be encouraged to enroll in the same classes as students from other schools).

This would mean the adoption of at least a part of any biological science "core program" that is offered. However, the "core program" should be sufficiently flexible to allow access to and departure from it according to the needs of the students. Ideally, the "core program" should begin with the familiar and proceed to the unfamiliar. Instruction should begin with the organism and proceed toward an integration of functional and morphological relationships at the molecular, sub-cellular, cellular, tissue, organ, organism, population and community levels.

By the junior year, the agricultural student should be well prepared to take courses related to his professional interests. Two general curricula should be available to him in each field of specialization, namely, a science curriculum and a technology curriculum. In the former, emphasis on the basic sciences would be continued but professional courses would be included. In the latter, cultural practices, industrial applications, etc., would be emphasized. So that a student might retain emotional and professional attachment to a particular agricultural discipline, he should be allowed, but not compelled, to identify himself with the relevant department for counseling and registration at any time during his first two years at the university. For the same reason, it would be advisable to include in the freshman curriculum an intensive course designed to relate the basic sciences to the student's professional interest. It should not, however, be a prerequisite to any other courses.

The basic sciences should be sufficiently comprehensive to provide students of agriculture with information pertinent to their professional needs. In those instances where this is not the case, three alternatives may be pursued: (a) a conjunctive tutorial section (or recitation) could be offered for credit under the direction of a professor capable of relating the principles discussed in the basic science classes to problems of agriculture; (b) a special group or department that has evolved from the "new biology" (e.g., a group in biophysics, mathematical biology or biochemistry) could be encouraged to offer a high-level course which would satisfy basic agricultural requirements; (c) a <u>comparable</u> course could be taught in the college of agriculture by a <u>qualified</u> professor who is conversant and sympathetic with the problems of agriculture.

If either of the latter two alternatives is adopted, the course should be of such a nature that it will qualify the student to take more advanced courses offered by the school administering the relevant basic sciences.

RECOMMENDED CURRICULA FOR PLANT AND SOIL SCIENCES

The the foregoing philosophy in mind, the following curriculua for students in plant and soil sciences were formulated. These curricula were intended to serve only as guides. Each university may develop its own innovations.

I. Required Lower-division Courses (both science and technology curricula)

	Semester Hours (approx.)
Agricultural Science (freshman year) An intensive course illustrating the impingement of science on agriculture	3
General Biology - This two semester integrated course should contain elements of conventional botany, microbiology and zoology as now being taught. These should be upgraded, however, to reflect the current improvement of high school biology. If unprepared for this course, the student should be required to make up his deficiencies during the freshman year.	8-10
Cell Biology - This course should be essentially biochemistry but should be taught with strong emphasis on the relation between function, structure and inheritance of the various cell components.	4
General Chemistry - Should include general and inorganic, quantitative and qualitative anaylses, preferably taught in one academic year.	10
Organic Chemistry - Fundamental principles of Organic Chemistry	4-5
Introductory Calculus (Mathematics 1*) Differential and integral calculus of the elementary functions with associated analytic geometry. If unprepared for this course, the student should be required to make up his deficiencies during the freshman year by taking Precalculus Mathematics (Mathematics 0).	3-4

* The mathematics courses included in this report are the ones identified by the same numbers in the 1965 report on A General Curriculum in Mathematics for Colleges. The Committee on the Undergraduate Program in Mathematics, P.O. Box 1024, Berkeley, California 94701.

	Semester Hours (Approx)
Probability (Mathematics 2P) An introduction to probability and statistical inference making use of the calculus developed in Introductory Calculus. In those cases where additional mathematics will be a part of the recommended curriculum, the student should be permitted to take Mathematical Analysis (Mathematics 2,4) and Linear Algebra (Mathematics 3) before taking this course.	3
General Physics - The principles of physics including mechanics, heat, sound, light electricity, magnetism and elements of modern physics.	8-10
Earth Science - Two one semester courses should be required in this group. Recommended courses should be Physical Geology and Climatology.	6
English and Communications - Two one semester courses should be required in this group.	6
Humanities - Two one semester courses should be required in this group.	6
Total	61-67 hours

II. Recommended Upper-division Courses (science curriculum only)

Recommended upper-division courses will depend on the professional interests of the student. The courses will not be the same for every plant and soil science discipline. Also, in a given discipline they will not be the same for the science curriculum as for the technology curriculum. (Upper-division courses for the technology curriculum have not been considered in this report.)

In Figure 1 is shown the minimum number of semester hours that students in the different current or prospective agricultural disciplines should be encouraged to take in each of the traditional subject matter areas if these areas are not integrated into some kind of a "core program." In view of the desirability of allowing ample time for electives, the total number of hours recommended for each discipline is prohibitive. Further, the chart indicates too much fragmentation of subject matter.

Therefore, it is strongly recommended that the courses involving plants be combined into two consecutive four-hour courses in Advanced Plant Science. These courses should be devoted largely to a consideration of:

the structure and function of higher plants,
the growth of higher plants,
the reproduction of higher plants,
the environmental relationships of higher plants, and
the evolutionary relationships of higher plants.

A similar integration of courses in soils may be desirable.

A student taking the required lower-division courses and the recommended upper-division courses should be adequately prepared either to go on to graduate school for further training or to assume a responsible technical role in his profession.

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FIGURE 1. Recommended Upper-division Courses for Current and Prospective Areas of Plant and Soil Sciences.

	Genetics	Plant Physiology	Ecology	Taxonomy	Anatomy	Pathology	Entomology	Microbiology	Soils	Phys. Geog.	Phys. Chem.	Mathematics	Statistics	Biochemistry	Morphology	Physics	Computer Sci.
Horticulture	3	3	3	3	3	3	3	3	3		6	6		3			
Forestry	3	3	6	3	3	3	3		3	3		6	3				3
Botany-Plant Path.	3	3	3	3	3	3		3	3					3	6		
Range Management		3	3	3	3		3		3	3				3	3		
Soil Science		6	3					3	18	3	6	9	3			3	
Crop Science	3	3	3		3	3	3		6	3	6	3		3			
Space Agriculture		6	6			3	3	6			6	6		3		3	3
Ecological Engr.	3	6	6+	3					3	3	6	6			3	3	3
Systems Agriculture		6	6								6	9	3			3	6