Requirements in the Physical Sciences for Students in Agriculture*

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It is a formidable task to discuss cogently the question of requirements in the physical sciences for such a heterogeneous group of students as we have in this broad field called agriculture. In discussing the topic with my colleagues at Colorado State University, I received the anticipated diversity of opinion; scarcely two of you in the room today are likely to agree very closely on what should be required of students in the area of physical sciences . . . all of which should make for some interesting discussion after I have thrown out my thoughts and personal biases!

Many factors determine the depth to which a student should pursue the physical sciences; among these are first, the impact of course work on the student, and second, the type of institution attended. We will discuss these briefly. But the principal factor is the career objective of the student, and the major part of my presentation will focus on this aspect.

My discussion today will center on the physical sciences only rather than the broader aspects of the natural sciences which would include all of the biological sciences, zoology, botany, physiology, microbiology, etc. – which would, in these days of "revolution", generate several more discussions each longer than the present one. We will discuss then, only the classical physical sciences of mathematics, physics and chemistry with a brief mention of statistics, geology and atmospheric science.

First, then, we should face the rather humbling reality, known to most of you but re-inforced recently in the study by Blackburn (196?) of student opinion at Michigan – namely that formal course work, classroom assignments, and even the mighty professor himself, all apparently have relatively little lasting impact on the student. These students, typical, I am sure, of most across the land, had forgotten the names of most of the teachers they had had, even those in the semester of the survey; they knew none of the names of the authors of their textbooks or even the titles of the texts, but only that they were using a "small green book" or a "thick black covered book with no pictures in it"! The lasting impressions were apparently being made by the students' peers, by the extra-curricular activities, by their social engagements, etc. Furthermore, it appears that many large companies who hire students frequently care little about the exact nature of the curriculum followed by the student, or even his major field, just so long as his record is reasonable and the university has stamped "approved" on him by awarding him a diploma! Humbling indeed to be relegated to a role of such insignificance!

But I am sure that all of us are more optimistic than this about our impact on the student: as Hess (1968) has so nicely expressed – "Our mission is to facilitate or expedite the educational process; we cannot give students an education – no College can. Education depends on the student's attitudes and what he does. But we can challenge his intellect. We can give him a sense of exhilaration with fresh discovery. We can open doors for him and we can, as teachers, transmit contagious enthusiasm for inquiry. We are responsible for providing students with facts, concepts, principles. We are also responsible for relating the tools of a given discipline to the larger context in which the tools will be used. We must help develop the students' ability to think, i.e. the ability to dig out facts, analyze them, discard the irrelevant and come to a decision based on the facts. Facts are merely a means to an end – for the development of thought. We have failed if we merely stuff students with facts without teaching them how to use the facts, and how to get new facts to meet the new problems they will face."

This leads us to the reason why the physical sciences have a place, an ever more important place in the view of many teachers, in the curricula in agriculture. For the study of agriculture is becoming annually, if not daily, more scientifically oriented; today's students in agriculture must be and frequently are more interested in the underlying scientific and economic bases for agricultural practices rather than in the cook-book recommendations of the past decades. They are, too, better prepared from high school mathematics, physics and chemistry to master the scientific aspects presented to them. If we teach them the principles, surely they will be better prepared for tomorrow's world.

We must recognize secondly the wide variety of *institutions* in which agriculture is taught – from the land grant institutions which now mainly call themselves universities and which generally have fairly extensive experiment stations with large research programs and correspondingly heavy and specialized staffing (up to 100 or more men); through the four year colleges with moderate programs and staffs (say half-a-dozen to ten men); to the two year community and junior colleges in some of which agriculture plays a relatively important role and the staff may number as many as ten or a dozen men; to the same kind of institution with one or two men in agriculture; and finally to the growing number of vocational-technical institutions which no doubt will in the future accept many of the responsibilities previously undertaken in the practical training of students by the junior colleges and even in many of the land grant universities.

Thirdly, and allied to the diversity of institution but probably much more important in the consideration of physical sciences requirements is the question of career aims of the students involved in the programs. I will divide these into three major groups. A small number will follow in our own footsteps, into graduate schools to pursue a career in teaching and research. A further significant proportion will prepare themselves to return to the practical conduct of an agricultural operation – farm, ranch, feedlot, etc. But perhaps the major portion of the students will enter that great amorphous area known generally as "agribusiness".

Bearing in mind that we will be educating students who will be the leaders at the beginning of the 21st Century, what then should be the requirements in the physical sciences for each of the three categories of students described above:

For the first group, those who will become teachers and researchers and who will graduate primarily from the land grant universities, there should be little problem of motivation and little argument about recommending as much basic science as they can absorb; mathematics through calculus and perhaps even differential equations if they remain "turned on" by the subjects; with a first rate high school background, students can now reach this level in only four or five terms of math; with aptitude but weaker backgrounds it may take as many as 7 to 8 quarters or 6 semesters. In chemistry, the sky's the limit; inorganic to introduce the subject, a mild dose of physical chemistry, a solid background in organic, and finally, as much biochemistry as can be worked into the student's program. My colleagues are currently complaining about the latest breed of biochemist however; the trend apparently is toward overspecialization in the narrower realms of cellular biology and cytochemistry, leaving a great gap in the area that has been traditionally useful to agriculture; there seems therefore, to be a growing but already reasonably acute need for courses, and perhaps even programs, in "Agricultural Chemistry" to serve the needs in nutrition, soil science, fertilizer manufacture, insecticide production and use, as well as a host of other applications. The wheel needs perhaps to squeak in demand for oil!

In physics, the picture is much less clear; heretofore, we have assumed that a dose of physics was a good thing for *those following* a career in the agricultural sciences. But physics has always been heavily oriented toward engineering with its mechanics and dynamics and optics. And while proficiency in physics may be desirable for "ye compleat scientist", it is not at all certain that some training in physics could not be sacrificed in preference to additional in-depth training in biochemistry. Predictably, this suggestion, in these days of competition for more students to teach to justify bigger instructional budgets, does not receive a very hearty welcome in departments of physics! Incidentally, most of the physics necessary for a reasonable understanding of say, physical chemistry or physiology, can be and frequently is taught in these subjects themselves, in the introductory parts of the course.

For the second group of students, who will return to "production agriculture" in all its diverse forms, there is room for much more debate and disagreement! But my personal philosophy is that to train the leaders for an ever-more scientific agriculture we should be advising students into a fairly strong program in the basic disciplines. This is easier to say than to accomplish however! No doubt you have all had the same experience as I in trying to advise a student to take an extra course in math or chemistry! And you have no doubt heard students in their final quarters, or even years after their graduation, express regret that they had not signed up for more math or more chemistry (a few rare ones have even regretted not taking more English!) But as freshmen or sophomores, they will never listen to such advice.

There are two possible solutions; the first is to teach the introductory course in the student's field in such a dynamic and revealing way that he will see clearly the necessity for solid training in mathematics and chemistry if he is truly to understand agricultural science. The second is for us to teach much more of the basic disciplines in our own courses in say, nutrition, soils, crops, genetics – for instance to interweave chemistry through the student's entire academic career; in this way, too, chemistry can very well be made much more "relevant" to the student, since he sees the immediate application of the discipline to his field of immediate interest. I have many times had this reaction from students when I introduce Statistics in the course I teach in Animal Breeding: the correlation between the weaning weight of a calf and its subsequent gain in the feedlot is much more meaningful to a student than the raw correlation between two variables X and Y!

But how much is required for this group of students? No great depth in mathematics, in my opinion – a good solid course in algebra to give a thorough appreciation of the subject; no physics needed here, beyond the high school appreciation gleaned in their science course; but the more chemistry they can digest the better – more and more of practical agriculture involves chemistry, from soil fertility to hormone implants, and the agricultural producer is beset with claims in advertising and promotion that demand a familiarity with the principles of chemistry. An introduction, at least, to biochemistry is highly desirable.

These practically oriented students could well profit from an exposure to geology, especially those returning to farming, to give them a deeper sense of appreciation of the origin of their soils. The same group would derive some benefit from atmospheric science, to aid in the understanding of weather patterns.

The last group of students, destined to enter "agribusiness" will be steeped in the theory of economics and the principles of business but will need also a fair familiarity with mathematics and chemistry. Training in statistics is preferable to deep mathematics, since the business world deals heavily in statistics and statistical problems. Again, since these students, too, will deal with businesses and products that are rooted in chemistry, they should have a good introduction to the field, preferably as far as organic chemistry.

In conclusion, there is little question that all students in agriculture should take enough physical science to give him a thorough grounding. The exact depth is difficult to specify precisely, but should be determined by the career objectives of the student.

Western Style Barbecue

CHARTER MEMBERS PRESENT AT 1971 CONFERENCE: Left to right – T. R. Buie, Southwest Texas State University; Carl Schowengerdt, Southeast Missouri State College; Clyde Hyder, Tennessee Tech University; Ralph Benton, Southern Illinois University; Conrad White, William Penn College, Oskaloosa, Iowa.

Technology and the Bioenvironment – A College Course

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Introduction: The actions of organisms affect their environment. The actions of the organism man are such that they have tremendous environmental effects, both quantitatively and qualitatively. In the short run, man seems to be affecting the terrestrial environment more than any creature in history. Perhaps, the activities of man in the United States represent the extreme case.

Recently, the news media have directed public interest toward the quality of the environment. Television has been particularly effective in this. It is interesting to speculate on why this emphasis has occurred at this particular time in history. Perhaps the news media had exhausted all other crusade possibilities or perhaps public figures saw a promising bandwagon that would further political careers. Regardless of what the purposes were, I feel that the interest is a healthy omen in our society and should