ing activities in agriculture and other vocational fields. Our Center is comprehensive in its interest and commitment to vocational and technical education, interdisciplinary in its approach, and interinstitutional in its program. We hope you will look upon it as a potential resource.

What about the future of vocational and technical education? In my judgment, the biggest question is, "What kind of future do we want?" In the last few years a number of organizations and government agencies have begun to anticipate or "invent" the future. Our achievements in defense and space endeavors may have given us the impression that we can literally invent the future if only we are willing to devote the necessary men and money. To achieve this Utopian concept in agriculture will demand the best thinking and efforts of all segments of the agricultural education community. Furthermore, it will necessitate improved coordination and cooperation among all relevant groups. The effectiveness of programs of the future can well hinge on the manner in which we perceive our present circumstances, identify long-range goals, consider alternatives, develop effective working relationships, and execute our plans and responsibilities.

I predict that we will not be content to merely keep up with change, which is the key to survival; rather, together, we will create change, which is the key to leadership.

"Our Brethren Are Already In The Field"

GEORGE A. GRIES, *Head,*
Department of Plant Pathology
University of Arizona

"Our brethren are already in the field. Why stand we here idle?" With these words Patrick Henry spoke with alarm about the complacency of his fellow Virginians, while others, with no more at stake, were already at war. Perhaps the same words are appropriately directed at those of us in the field of education in agriculture.

Over the past ten years it has been popular to extoll the Colleges of Agriculture in the United States and to give them credit for almost single-handedly bringing about many of the desirable features of American life. We have heard that as a result of agricultural research, an ever decreasing percentage of the American public is needed for primary production, and that this in turn has released manpower to produce luxury items which contribute to the high standard of living we enjoy. We also hear that, to the credit of the agricultural colleges, the American workingman can buy a T-bone steak for a few minutes work while a Russian has to work long hours to obtain his tough little piece of boiling beef.

These ideas, no doubt, have had their place in boosting our morale in an era when agriculture was taken for granted and its image was at an all-time low. I wonder, however, if they have not had another, less desirable, effect — that of lulling us into complacency, into thinking that the organization and the system that have been so fruitful in the past can continue to serve effectively without change in the years ahead.

Students entering our colleges this fall will graduate in 1970. They will be among the leaders in the field from perhaps the year 1980 to the year 2000. Is the training that they are now receiving that which they will need to fulfill the responsible roles awaiting them? Perhaps a quick look at the agriculture of the not-too-distant future will give us an insight into some of the questions and problems with which they will be faced.

Farming in the United States will be a corporate enterprise; the small farm probably can not persist. Cultural practices will be programmed by computer, perhaps not for maximum output, but for optimum efficiency in the utilization of water, land, labor, and capital investment. Ecosystems will be controlled and modified by chemical, physical, and biological means. New resource areas will be exploited including subpolar regions, arid lands, and, yes, even the seas and space. Marine agriculture and space agriculture are almost foregone conclusions. Who will manage the production of biological resources in the seas and who will be growing plants, and maybe animals, under pressurized, artificial environments on the moon? These possibilities are no more remote now than was the application of hydroponics to growing food on coral atolls in the Pacific at the beginning of World War II. If agriculturalists are not to do these things, who will? Who else is so well trained in the principles of management of biological commodities?

New concepts of the genetic potential of plant and animal species will be developed. In a recent talk, Dr. James Bonner of the California Institute of Technology suggested one example. The succulent plants as a group are most efficient in the utilization of water per unit of dry matter produced. This results from their unique ability to fix carbon dioxide in the dark while their stomates are open; during the day while stomates are closed and water loss is minimized, this temporarily fixed carbon dioxide is used in photosynthesis. Dr. Bonner points out that only the pineapple among our cultivated plants has this singular type of metabolism. The agricultural and chemurgic potential of other succulents has not been assessed.

We may also expect that the metabolism, growth and development of both plants and animals will be more closely controlled by means of chemical regulators. Those who use them will have to understand their action.

Opportunities in foreign agriculture will expand for those who have the ability to adapt their knowledge to new problems and to different social and political environments.

Many of you will immediately agree that the agricultural research scientist of the future will have to be better and more broadly trained than his counterpart of yesteryear, but some of you are not willing to admit that the training program for the agricultural technologists will also have to be changed significantly. While I agree that there will continue to be jobs *not greatly* different from those of today, it is my firm belief that the training of the terminal B.S. will have to be modified drastically. The industry will demand personnel at all levels of

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training with better backgrounds in the basic disciplines — persons who can adapt more readily. In-service and on-the-job training programs will become more common, and the colleges and universities will be expected to place more emphasis on basics and less on "training for the first job." If we do not, the industry will look to biologists, chemists, physicists, and even the engineers to fill their needs. The agriculturalists will have to be satisfied with only the most routine and commonplace of tomorrow's activities. Then what will our image be?

Within the last ten years the teaching programs in the natural sciences and especially in the biological sciences have undergone dramatic changes. The K-12 (Kindergarten through High School) program of the American Association for the Advancement of Science is stimulating interest in science and catalyzing further study on the presentation of scientific reasoning to grade school and secondary school youngsters. The Biological Sciences Curriculum Study (B.S.C.S.) program has had a strong impact on the teaching of biology in high school, and the effects of it are just beginning to be felt in the colleges. Changes that are equally exciting and challenging are occurring at the university level, and these particularly will have a significant impact on instruction in agriculture in the years ahead.

The new advances in knowledge in the biological sciences have been primarily in the areas of molecular and cellular biology. This is a reflection, in major degree, of the increasing use of the interdisciplinary approach to the solution of problems — an approach that has made almost obsolete the traditional differences between the various basic sciences. A series of discoveries at the molecular level, including the role of DNA and messenger RNA, have demonstrated that the cell operates in essentially similar fashion in all biological entities. Now botanists, zoologists, and microbiologists are seeing unity where before they saw only diversity. Is it any wonder then that we are now hearing such terms as integrated biology, molecular biology and cellular biology in place of the old terms, botany and zoology? And is it any wonder that many biologists are revising their curricula to conform to these newer concepts?

With a great deal of foresight the American Institute of Biological Sciences created, in 1962, the Commission on Undergraduate Education in Biological Sciences (CUEBS) to give encouragement to curricular study and guidance to orderly change. Like its counterparts in chemistry, physics, and mathematics, CUEBS has assisted in the exchange of ideas and information and has cooperated with and coordinated the efforts of faculties, institutions and professional societies. With no intention of dictating policy, CUEBS has as its goal the stimulation of constructive thought that will lead to improvement of biological education.

There are among the biologists, and I fear among agriculturalists too, those who have their heads in the sand. They seem to believe that the new interests and new approaches are fads, that will, if ignored, go away. No doubt many of the new curricula and many of the new courses are extreme; they will be modified and perhaps drift back more nearly to the traditional. I am certain, however, that he who waits for college biology to revert to its static position of description and nature study of 10 years ago waits in vain. It will not, it cannot, it must not be thwarted in its attempt to gain its rightful position as a modern science. The "new" biology has much to offer general education and it can contribute greatly to agriculture and the other disciplines based upon it. It also is finding new horizons for itself as a basic discipline. It must be allowed to develop even though it means a period of ferment and indecision. Agriculture should assist it in its groping and work to help it develop programs that will be of maximum value to agricultural students.

The total subject matter of biology can be subdivided in many ways. Traditionally, we have divided it vertically into plants, animals and microorganisms and then subdivided it into convenient but artificial and isolated categories such as taxonomy, anatomy, and physiology. Students might take these courses in any sequence or might elect only one or two of them. It was thus impossible to integrate the subject matter of the different courses, and much duplication occurred. Similarly, it has been difficult for us to articulate our courses in "applied biology" to the basic offerings, and again excessive duplication has occurred.

Some would suggest that we divide biology horizontally into a series of courses on the basis of organization level. Since molecular activities are largely common to all organisms, they would start there. Next they would look at the cell as a basic functional and structural unit of life, and progress through tissues and organs until they finally reach the organism. Later they would undertake the study of populations of organisms and the impact of the environment on their performance. It is frequently suggested that this is the logical approach to the study of biology. Logical? To whom? Obviously it is logical to those who are biochemically or biophysically oriented, but it most certainly is not to those who derive their interest and motivation from the whole living organism. It is not the logical approach for students in the College of Agriculture.

The ideal curriculum in biology must give due weight to all groups of organisms and the features that make them unique and distinct from others. It must also give students an understanding of biological unity at the molecular and cellular levels, and some insight into the behavior of populations of organisms. All modern curricula attempt this; they vary only in emphasis and time to accomplish it. On some campuses biology has moved so far away from the traditional that it has been dropped as a basis for agricultural courses. On others, biologists and agriculturalists have planned together to assure articulation between the offerings of both. On many campuses changes have been slow to come, but they will come, and I urge agriculture to work hand in hand with biology to make the transition as smooth and as meaningful as possible.

Efforts are underway on the national level to establish patterns for this transition. CUEBS has established a separate Panel on Preprofessional Training in the Agricultural Sciences. This group, working together with the Commission on Education in Agriculture and Natural Resources (CEANAR) has underway at present an in-depth study of the training in the biological sciences as well as a less detailed study of the mathematics and physical science needed by students in the different areas of agriculture. Although it is realized that there is a continuum of post high school training needs from the short course to teach a technique all the way up through the 4-year business, technology and science options leading to the Bachelor's degree, this study is concerned primarily with the baccalaureate programs. Similar attention should be given to the biological training needs of those enrolled in non-degree programs.

Rather than second guess those involved in the current CEANAR-CUEBS study and rather than claim to speak for the Commission, I would prefer, in the time remaining to regale you with some of my own beliefs on the effects that changes in natural science instructional programs will have on baccalaureate programs in agriculture and to expound some of my ideas regarding the training of the B.S. technologist of the future.

First, I would indicate that I wholeheartedly embrace the "core" concept — not only in biology but in the physical sciences and mathematics as well. I would stipulate, however, that every "core" have two characteristics: (a) that it give early and broad coverage to the entire field, and (b) that it have many points of departure.

In the case of biology the introductory course should emphasize, but not be limited to, a study of organisms and populations of organisms — the levels of organization with which we are most concerned and the level with the greatest potential for motivation of the student. In view of the wide range of backgrounds with which our students come to us, provision should be made for those with excellent preparation to receive advanced placement. Whether biology is to be taught at the freshman level as an integrated discipline or as botany and zoology is a continuing point of contention. There are logical arguments to support both views, but logic seldom prevails when this topic is being discussed.

That the core have many points of departure, I believe is incontestable. The variations in depth of background needed by the students in agricultural business, agricultural engineering, agricultural technology, and those preparing to enter graduate school in one of the more sophisticated biological specialties dictate that this be so.

Biology core programs are presently in a state of turmoil. It is doubtful that there will ever be one standard because of the variety of purposes biology serves. In liberal arts colleges it will probably always be oriented toward general education. In some schools it has been traditionally biased towards the pre-med student. In the larger universities it must serve a variety of students including those in agriculture. Physics and chemistry departments have only begun to consider their service role to other areas; but mathematics, on the other hand, has given much attention to the development of a sequence of courses that they believe will serve the needs of all students. This "core" is characterized not only by many points of departure, but also by many points of entrance.

There was a fad a few years ago to equate agriculture with science. Colleges and departments changed their names. Courses in Poultry Husbandry became courses in Avian Science. Some people in agriculture were impressed; some politely ignored this attempt at respectability; but most scientists in the traditional disciplines laughed. I'm afraid a number of high school and college students laughed too. To them biology, physics, chemistry and mathematics are *the* sciences; agriculture becomes an *applied science* only to the degree that it utilizes and applies these basic disciplines. Here we were teaching "agricultural science" to students with no workable knowledge of biology or physics or chemistry or math; and what was worse, we were not even using the backgrounds in these subjects that they did have in the development of our courses.

How often in your course with a prerequisite in organic chemistry and plant physiology do you really build on a concept that the student presumably learned in the prerequisite course? How frequently do you use higher mathematics, for example, in a discussion of the epidemiology of an animal disease? My effort here is to point out what I believe to be one of the greatest shortcomings of educational practice in agriculture: our failure to truly articulate our courses with those of the rest of the university or even with those in the students' backgrounds. While this is not entirely our fault, a major portion of it is. First, most of us are obsolete. Either we never were really qualified in the basic disciplines upon which our "applied science" is based, or we assume that the content of the present course in organic chemistry, plant or animal physiology, genetics, economics, and so on, are the same as they were when we took the course 20 years ago. Another factor that contributes to our inability to really challenge our students to apply basic concepts to our subject matter is that in order to fill our classroom with warm bodies we either omit legitimate prerequisites or we freely waive them. The students thus have such diverse backgrounds that we can't build on previously acquired information even if we were capable of doing it. Instead, we have to reteach material to the depth needed.

To summarize this point, let's look a little deeper at the mathematics requirements for the baccalaureate degree. We seldom require anything past algebra and trigonometry. We don't use it in our courses either because of lack of our ability or because some of the students have not had it. Therefore, the question is raised, "Why require it?" The technologist of tomorrow will be living in a mathematical age. The computer may solve the problems; but the man will have to understand the significance of probabilities, of limits, and other concepts to even interpret the answer that the computer hands him. In planning curricula for future students, don't sell them short. Prepare them for the era in which they will live.

I visualize that in the not-too-distant future the technical (and scientific) aspects of agriculture *will* be concentrated in the last two years of the baccalaureate program. There are two reasons for this: more and more of our students will be transferring into our four year programs in the junior year, and two years in the basic disciplines will be needed to gain the backgrounds that will be needed to teach the types of courses in agriculture that must be taught.

This does not mean that courses in agriculture should not be offered during the first two years, but let's not try to convince anyone that they are "science" courses. I visualize a course during the first year in which agriculture is approached through its socio-economic implications, both past and present. This course should also delve into the frontier areas of agriculture to demonstrate to the student the relation of the basic disciplines to the solution of the problems of the future. Show him why he will need calculus, physical chemistry, sociology and other courses if he is to compete in some area of agriculture 20 years from now.

Sometime before the end of the sophomore year introductory courses in crop production, animal production, soils, and the social sciences as they are related to agriculture could be offered. These should have few or no prerequisites and should be so taught that they would have campus-wide appeal. Neither should they be prerequisite for specialized courses to be taken later.

In closing I would make one final appeal. Realizing that 50 percent of the technical knowledge of today will be obsolete in 10 years, that 50 percent of the technical knowledge our graduates will need in 10 years has not yet been discovered, that, if he is typical, our graduate will make 4 to 6 major changes in his type of employment during his lifetime, and that he must live as a responsible citizen in his community as well as make a living, let us be certain that in planning curricula for the future, we put the good of the student foremost. We can and we must adapt to change, to the new curricula in biology, to the future requirements of the industry. Let us forget our vested interest in the *status quo* and move forward as the times demand.

Curriculum Development and the Larger Learnings

by
WILLIAM F. BRAZZIEL
Director of General Education
Virginia State College
Norfolk, Virginia

Curriculum development utilizing reasoned principles and directed toward reasoned goals in liberal learning is a challenge of the highest order to faculties in these times. First, there is the great challenge of trying to have the faculty agree on something — not only on one item but on an entire spectrum of