# FINAL WORD

by David Pramer, Ph.D.

## ENSURING QUALITY EDUCATION IN BIOTECHNOLOGY

Biotechnology is certainly not new. It was practiced by ancient man for the production of fermented food and beverages, and gained prominence during World War I when acetone and glycerol were produced by bacteria and yeast, respectively, for the manufacture of munitions. These processes led after World War II to the development of an important fermentation industry responsible for the production of penicillin, streptomycin, and other therapeutically important antibiotics. Fermentation technology now is used to produce enzymes, amino acids, and various other metabolic products of microorganisms on a commercial scale. This important evolutionary development over the decades went almost unnoticed until the 1980s, when the rubric biotechnology suddenly emerged as a major concern of science and society. The current focus of interest on biotechnology results from a number of developments, including the search for alternatives to fossil fuels caused by escalating energy costs, the protein shortage so evident in developing regions of the world, the development of new fermentation equipment and bioreactors with enhanced industrial potential, the improvement of cell-culture and cell-fusion techniques, and, finally, the much publicized development of recombinant DNA procedures capable of programming bacteria and other cells to make things they have never made before.

Biotechnology is a challenge that educators cannot ignore. However, today's biotechnologists were not trained as such. They came mostly from traditional fields of science and technology with individual training in biology, chemistry, or engineering. Together, they have labored to build interdisciplinary bridges, constructing centers of intellectual activity where novel processes and products are created for the benefit of human health and well-being. All this brings a new luster to a career in research, making universities more attractive to many of this country's most promising young people. However, when those answering the call arrive as students at the schools of their choice, it is doubtful that they will be able to locate a program in biotechnology.

Biotechnology may be defined as the utilization of microbial, plant, or animal cells, or their constituents, to provide goods and services. Biotechnologists must learn the practical side of science. They must practice science as a skill, and to do so they must be skilled scientists. Therefore, it would be unwise for universities to offer educational programs in biotechnology that are narrowly conceived or overly professional, and it is essential for university scientists within traditional academic disciplines not to abdicate a responsibility to educate biotechnologists.

It has been estimated that more than 35,000 biotechnologists will be needed in the U.S. by the end of this century, but research universities deserving of the name should be interested more in quality than in quantity. They should not sacrifice long-term benefits for short-term gains. In the past, some universities explored new organizational approaches and novel interactive relationships for cross-disciplinary programs of education in environmental science, space science, cancer, crime, and energy. That experience can be used to advantage now to design programs in biotechnology.

Biotechnology is a labor-intensive, science-based industry, and biotechnologists require quality education in the sciences. The industry was created by university graduates with degrees in chemistry, biology, and engineering. To continue to flourish, biotechnology must be nourished by a steady supply of individuals who also are well educated in traditional disciplines, and who are taught a respect for the application of science as well as for science itself. Since biotechnology five years from now may be quite different from what it is today, the key to educating a biotechnologist is flexibility in specialized aspects of a program that is firmly based in science and engineering.

Within a university setting, separately organized research centers have served successfully as vehicles for faculty members to pursue professional interests beyond the constraints of traditional departments. They facilitate cross-disciplinary cooperation for the solution of problems of intellectual and societal importance and introduce diversity into institutions of higher education. Separately organized research centers maximize visibility and enhance institutional prestige, making the university more attractive to scholars, to undergraduate and graduate students, and to funding agencies. They are a major device employed by leading universities to conduct training and research in areas like biotechnology which are deserving of special attention and priority. A separately organized biotechnology research center would be able to forge educational programs appropriate for training predoctoral and postdoctoral students and it could function also as a source of continuing professional education.

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Students associated with the center should study a chosen discipline in depth and complete the requirements for a degree with a major in an area such as biochemistry, genetics, microbiology, or chemical engineering. In addition, students should be awarded a Certificate in Biotechnology in recognition of their participation in a selection of special educational offerings designed as an introduction to biotechnology. A joint seminar is one way to acquaint students with the difficulties of communicating across disciplines and to teach the importance in biotechnology of interdisciplinary literacy. Of equal value would be a special topics course that familiarizes students with the principles

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ary, cooperative advance between man and other life forms which biotechnology represents and counter the concept of natural disruption now associated with other technologies, especially nuclear technologies. To reinforce this effort, the tradition of fermentation, its safe use in the wine, cheese, and pharmaceutical industries, and its link to the new technologies should be introduced as new fermentation products are introduced. The stability, the safety, and the reliability of such procedures should also be stressed.

An industrial pre-marketing consumer education effort should also emphasize aspects of biotechnology which counter some of the current prejudices against other technologies. Consumers who rightly fear acid rain and meltdowns may be less reluctant to accept biotechnology products when the "clean" aspects of these processes are emphasized. The potentials for substituting enzymatic reactions for toxin-producing chemical reactions, the ability to develop non-polluting alternative energy forms, and the development of environmental monitoring products can be used as potent contrasts to the current view of technological evils.

The network for preparing consumers for biotechnology already exists in the marketing and public relations departments of corporations. The multimillion dollar budgets for reaching consumers through media and educational programs also exist. If corporations decide to use these resources with the same foresight and strategic planning which has characterized biotechnology research, the public can be prepared to accept and benefit from the proliferation of new products which will be introduced in the forseeable future.—**Christopher Edwards**

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that the chances of finding something interesting would be greater with only 100 new compounds screened chemically and given biological tests, than with 10 000 microbial strains examined by traditional techniques.

"The theory determines what one observes," Albert Einstein once said. The verdict of history may well be that Hans Zähner is the man who, during the 1980s, altered the whole course of applied microbiology by crucially altering those rules of observation.

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and practices of biotechnology and provides an insight into how, from the perspective of their individual disciplines, students will best be able to contribute to progress in the field. As a third possibility, the certificate program might arrange for students to spend time working in the laboratories of biotechnology companies where they will gain respect for applied science.

Certificate programs are not without problems. However, they are not disruptive to traditional departmental authority, nor do they widen the division between members of the program and their colleagues who do not participate in the program. They require no major changes in the operation or organization of university administrative structures, and certificate programs have the additional advantage in that they self destruct when interest in the field diminishes or disappears.

The system recommended here of a separately organized center and a certificate program in biotechnology complements the activities of traditional departments and offers the advantage of perpetuating a close association of research and teaching which is characteristic of quality higher education in America. It already has been implemented by some leading universities and is deserving of serious consideration by others intending to capitalize on the opportunity biotechnology has created.