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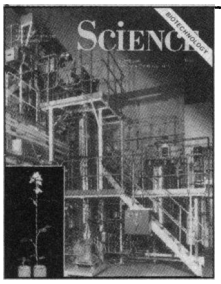
■ The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objects are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.



COVER Two sides of biotechnology. (Background) Large-scale cell culture has become a multimillion dollar industry, vital to the manufacture of vaccines, monoclonal antibodies, and other pharmaceutical products [1000-liter fermenter, courtesy of Celltech Ltd., Slough SL1 4DX, United Kingdom]. (Foreground) By selective breeding in the laboratory, rapid-cycling *Brassica campestris* plants have been developed that will be useful in basic research, in improving crop production, and as educational tools. See page 1385. [Paul H. Williams, University of Wisconsin, Madison, WI 53706]

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The Biotechnology Issue

President Kennedy once invited a large group of distinguished scientists to the White House for dinner and there remarked, "I think this is the most extraordinary collection of talent, of human knowledge, that has ever been gathered together at the White House, with the possible exception of when Thomas Jefferson dined alone."

Adapting this observation to the new biotechnology industry, we might say that we are today mobilizing the most amazing collection of brains for a new technology since Louis Pasteur worked alone. The biotechnology industry has been around for a long time, starting with the herb doctors and wine-makers of ancient civilizations. For deliberate application of the problems of science to the needs of health and the economy, however, Louis Pasteur is unique. He represents in one person the combination of pure research and practical application that is the hallmark of the current biotechnology industry.

In Pasteur's early studies he pursued the academic problem of optical antipodes, performing his classic work on the separation of dextro and levo tartaric acids. He also performed his seminal studies on the spontaneous generation of life, demonstrating that fermentation was the product of living cells and that life was necessary to create new life. His understanding of microbes and their behavior was the handle in his generation that recombinant DNA is in ours. Pasteur's genius and the smaller size of his scientific world produced a different relationship, however. Pasteur personally was involved in one major industrial application after another. He discovered the cause of the souring of wine and beer, thereby providing enormous economic savings for his own country as well as England and Germany. He corrected the devastation of the silk industry by identifying the parasite preying on the silkworm. He developed the technique for attenuating viruses and protected chickens from cholera. He then studied the disease of anthrax and demonstrated the protection of sheep in one of the great experiments illustrating the scientific method. In the culminating act of his incredible career, Pasteur saved the life of a young boy who had rabies by giving him ground-up tissues from organs of infected animals.

The modern technology industry parallels in uncanny ways the approach of Louis Pasteur. Its hallmark is the continuously changing line between basic academic research and practical industrial applications. Basic research in academia leads to applications in industry. Questions posed by industrial problems generate new academic initiatives. To the credit of many modern biotechnology companies, they have become more permissive in allowing their scientists to publish and less secretive in regard to their procedures than the pharmaceutical industries in the past. It is a farsighted approach, since secrets are difficult to secure and the industry itself thrives on the constant interaction with academia.

This issue of *Science* deals with new advances from which new medicines and industrial products may be produced. Even those who do not like broccoli will have to concede that a member of the broccoli family that goes through its life cycle in 6 weeks can provide a powerful research tool for plants (Williams and Hill). Vietmeyer describes some "poor people's plants" that may provide more new bases for industrial crops than the 20 species on which most modern agriculture now focuses. Parkman discusses those diseases for which bone marrow transplantation is most appropriate, a technology whose importance is accentuated vividly by the Chernobyl disaster.

Arathoon and his colleagues describe the improving expertise in growing large amounts of mammalian cells, a critical requirement for such products as vaccines, interferons, and monoclonal antibodies. Blumenthal provides insight into the opportunities and hazards of university-industry relations, and Dibner discusses the growth of biotechnology in Europe. Weetall and Pitcher describe factors involved in scaling up an immobilized enzyme system.

It is worth noting that Pasteur operated with an incredible freedom not given to modern researchers. His treatment of the boy bitten by a rabid dog was done without extensive field trials, which would have delayed its application for years. His studies on soured wines and diseased silkworms were not greeted with cries that he was introducing organisms into the environment. Allowing one genius unparalleled freedom is easier than attempting to control a boisterous and explosively growing technology. Pasteur's willingness to take risks for good cause and to tackle academic and practical problems with equal enthusiasm are standards of conduct that have aged as well as the wines he preserved.

—DANIEL E. KOSHLAND, JR.