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# Excursions in Biotechnology

Today's recombinant DNA biotechnology has brought with it the usual concomitants of basic research, applied research, and happy accidents. Some individuals worry that science has blurred the lines of demarcation between universities and industry. Their concern is probably justified. Others worry that many biotechnology companies are in financially shaky condition. They are accurate observers. Still others are euphoric about biotechnology; they await a grand flowering after a rather anemic beginning. Their expectations may also be justified. For the accomplishments of the still infant biotechnology industry, its promises of new procedures and new products, to say nothing of its ever more efficient production of goods, are awesome.

Biotechnology already permeates too many fields to describe them in a definitive fashion; only a few samples can be included in this issue of *Science*. Some of these deal with new areas of research that have great promise but are not yet ready for industrial application. Meyerowitz and Pruitt, for instance, describe studies of the plant *Arabidopsis thaliana*, which may become the *Escherichia coli* of the plant kingdom. Because of its small genome and small amounts of repetitious DNA, the ease of manipulation of this species suggests a future as a favorite experimental material for basic studies in plant development, and indeed of differentiation in general. Morrison describes new approaches to the production of novel antibody molecules, part mouse and part human. Her procedures are giving us insights into basic immunology and are also laying the groundwork for medical applications to autoimmune diseases. Some methods that are useful with small viruses, such as adenoviruses (35 kilobase pairs), are not applicable to large viruses, such as herpesvirus (150 to 250 kilobase pairs). Roizman and Jenkins describe advances in the manipulation of these inconveniently large structures. The procedures will be helpful not only in work with these specific viruses but also in using the viruses as carriers for additional vaccines.

Inasmuch as we wish to improve on nature, mutagenesis is employed with increasing frequency and potency. Botstein and Shortle summarize strategies for producing an enormous range of mutations: localized and random, in context and out of context. Other articles deal with processes closer to the chemical assembly line. Knorr and Sinskey discuss additives, safety, and quality control in food production and the structure-function relation of food materials. Smith, Duncan, and Moir describe procedures to produce the enzyme chymosin (also known as rennin); they used secretion from engineered yeast cells, a procedure in which a fully activable protein is formed in contrast to the insoluble inactivable protein that is formed if the enzyme is made in the cytoplasm. Thus, appropriate "ticketing" of a protein is crucial to its successful production. Perhaps the most interesting feature of each of these papers is the demonstration that the line between basic and applied research is almost impossible to draw. A basic finding leads to a new industrial procedure; a difficulty in applied technology requires a reevaluation of basic understanding.

Finally Dibner discusses the Japanese challenge, perhaps a necessary comparison for any technology article these days. The efficiency of the Japanese in organizing industry for the exploitation of fundamental research can elicit only admiration. Let me cite just one figure: the Japanese biotechnology industry introduced six times as many drugs per dollar spent on research and development as did comparable U.S. companies. Those in the United States who read this and the recent news items describing increasingly bureaucratic procedures for control of recombinant DNA in this country (News and Comment, 23 August, p. 736) may find it hard to hold back tears. We hope they do so, because the scientific frontiers that are being explored are so fascinating that making money may become incidental.—DANIEL E. KOSHLAND, JR.