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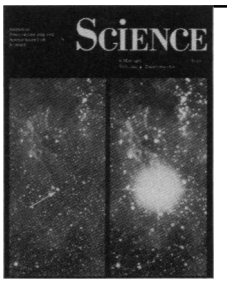

COVER Supernova 1987A—an exploding star. On 23 February 1987, light and neutrinos reached Earth from the brightest supernova in almost 400 years. "Before (left) and after (right)" photos show the star that exploded and the supernova shortly after outburst. Photographs were taken using the 3.9-meter Anglo-Australian Telescope in New South Wales, Australia. See page 750. [Courtesy of David Malin, copyright 1987, the Anglo-Australian Telescope Board]

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World Competition in Biotechnology

Virtually every developed country and many developing countries have targeted leadership in biotechnology as a national goal. In efforts to compete with the United States in applications of molecular biology to produce pharmaceuticals, would-be competitors are latecomers, with limited prospects. But in agriculture, the picture is quite different, and the United States could become second-rate. In the United States, generous support of biomedical research for decades led to great advances in molecular biology and to the training of a large number of talented people capable of advancing the biomedical sciences. Would-be competitors have limited reservoirs of expert personnel. Another favorable factor for the United States has been an abundance of venture capital, which was in short supply elsewhere. For some possible competitors the cost of development and clinical trials of pharmaceuticals ($75 to $100 million) needed to gain approval from the U.S. Food and Drug Administration is an inhibiting factor.

In contrast to federal support of biomedical research, funds for basic research in plant biology have been meager and the sums provided individual investigators have been tiny. Consequently, the knowledge base of the molecular biology of plants is limited. The level of conventional agricultural science in other countries is comparable to that here, and in some instances possibly superior. Expertise in the new biotechnology is widespread. Average yields of wheat per hectare in the Netherlands are more than twice those in the United States as are yields in the United Kingdom. There are mitigating factors, but these do not cancel the contrasts in yields. Our balance of agricultural trade has dwindled.

The crop surpluses in the United States have been used as an argument for curtailing research. However, if we move slowly in exploiting new biotechnology, we will lose competitiveness fairly rapidly. The time span and the investment required to introduce modified plants or symbiotic bioengineered microorganisms is small compared with that required for pharmaceuticals. Economics is one reason for pursuing vigorous development of plant biotechnology. Other benefits include diminished need for fertilizers and pesticides. Were productivity to be increased, less land would be required for crops, with less related soil erosion.

Major companies are devoting substantial funds to agricultural biotechnology. Their efforts are complemented by many new, small outfits. But progress has been greatly impeded by regulatory processes and legal actions. Although some caution in introducing new technologies is warranted, caution has been overdone. For example, there has been concern about introducing into the field a corn plant with a single altered gene. But Howard A. Schneiderman has pointed out that to convert a corn plant into a weed would require hundreds of genetic changes, because corn does not have a "weedy personality."* Regulations should take into consideration the basic characteristics of plants into which a gene or genes are to be incorporated. Some of our crop varieties require human assistance for survival.

Another area in which progress is being impeded is in the introduction of beneficial soil microorganisms. A prejudice exists against organisms whose DNA has been modified by recombinant technology. But during most of this century, rhizobia (designed to enhance nitrogen fixation) have been added to millions of acres of agricultural soil. Roughly 10^{18} rhizobia improved through mutation by chemicals or radiation are added each year. This release has not produced a negative environmental impact. Inoculants of selected mycorrhizae have greatly helped in restoring wastelands. In estimating potential hazards of introducing modified organisms, the gene's location in the genome is important. A gene located on a plasmid is much more likely to be transferred to another organism than is a gene that is part of a chromosome.

Advances in molecular biology have created great opportunities for advances in agriculture. The United States can persist in a policy of starving agricultural basic research and of overregulating biotechnology. Others may not follow such a path.

—PHILIP H. ABELSON

*H. A. Schneiderman, "Biotechnology: A key to America's economic competitiveness in health care and agriculture," speech at the Second Annual American Society for Microbiology Conference on Biotechnology, San Diego, CA, June 1987.