

BIOTECHNOLOGY, FOOD, AND BRAIN BANKS

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The manipulation of the biological system — biotechnology — and its recent offshoot, genetic engineering, have attracted considerable public and political interest because its breakthroughs have great potential in the fields of agriculture and health.

One technique, tissue culture, has been called "the botanical equivalent of the laser, in that there are more potential applications than originally conceived." The vast panorama of possibilities for the use of such techniques in agriculture, animal production, fisheries, and forestry is just unfolding.

Developing countries naturally want to avoid technological obsolescence and profit from the most recent advances in technology. They are thus attracted to the potential of biotechnology to solve problems of hunger, energy supply, and quality of life.

The precise priorities of these countries naturally vary widely, of course. The National Institute of Biotechnology and Applied Microbiology in the Philippines, for example, has accorded priority to research on biological fuels, nitrogen fixation by crops, food fermentation, production of antibiotics, vaccines, and microbial insecticides, and biomass production. India's National Biotechnology Board has chosen genetic engineering, photosynthesis, tissue culture, enzyme engineering, alcohol fermentation, and immuno-technology as areas of immediate interest.

Nearly all developing countries have plans or programs for harnessing biotechnology for their national development. It is important, therefore, that a realistic understanding of the problems and potentials associated with biotechnology research becomes widespread.

Food is the first need of humans. The world as a whole has been able to keep food production slightly above the rate of population growth, thanks in large part to new technologies leading to the development of high-yielding varieties of wheat, rice, and other major food crops.

The diminishing land resource for crop production is an important constraint. Farms in many Asian countries are shrinking under expanding population and demand for land. In most states of India, for example, the average size of a farm holding is less than one hectare. Increases in food production will thus have to come largely from increases in productivity and greater cropping intensity on land already under production.

This is where high-yield technology is of particular relevance. For example, in the Philippines, an additional 3.2 million hectares of cropland would have been needed to achieve the 1980 rice production level, had the high-yielding rice varieties not been developed in the 1960s. In India, over 34 million hectares of additional land would have been needed to produce the quantities of rice and wheat the country harvested in 1979, had it not been for the productivity advances made since the mid-1960s.

In spite of this impressive progress, the vulnerability of world food production systems, particularly to weather conditions, is very great. The UN Food and Agriculture Organization (FAO) study, *Agriculture: Towards 2000*, has shown that for the 90 developing countries as a group, the net cereals deficit of 36

million tonnes in 1978-79 will be doubled by 1990 and doubled again by 2000.

Can we integrate appropriate components of emerging technologies with traditional ones to find speedy and effective solutions to the problem of undernutrition and malnutrition?

Developing countries face the dilemma of having to improve both production and consumption simultaneously. Given the prevailing economic conditions in many countries, this will be possible only if the cost of production is kept as low as possible so that the sale price is within the means of a majority of consumers. The challenge to those in charge of technology development is to bring about a continuous improvement in productivity per unit of land, water, time, and energy without detriment to the long-term production potential of soil.

Can biotechnology help in this task?

BIOTECHNOLOGY AND RICE

The FAO has projected the need for an additional 300 million tonnes of paddy (threshed, unmilled rice) during the last quarter of the century. Unlike other cereals, the demand for rice will remain overwhelmingly for direct use as human food.

Through an expansion in the area under irrigation and through productivity improvement, it should be possible for developing countries to meet 200 million tonnes of the additional demand. It takes several years of breeding work to produce a commercially popular variety: The breeding of IR36, which is now planted in over 10 million

hectares in Asia, for example, took about seven years. Another two to three years is needed to produce sufficient seed to cover large areas. Thus, food production in the late 1980s will have to depend largely on the material already in the plant breeders' assembly line. The immediate task of research and development establishments should be to bridge the gap between potential and actual yields in small farmers' fields, by helping to eliminate the constraints that create this gap. Any new research program planned and initiated now will have delayed effects, increasing and stabilizing production only in the 1990s.

Yield improvement and nutrient supply in rice are areas of research where tissue culture and genetic engineering could be of great value. Even though basic techniques of biotechnology have been developed and known in the past, the application of these techniques to crop improvement is a new avenue of research.

Among various tissue culture techniques, the induction and selection of useful mutants is probably the most promising. At the International Rice Research Institute (IRRI), work on salt-tolerant varieties of rice is now under way. Work on high-lysine and high-protein rice will soon be initiated. Disease resistance can also be increased by tissue culture.

Incorporation of nitrogen fixation genes into rice by genetic engineering is the most ambitious project. This will help the rice plant to fix its own nitrogen from the air, eliminating the need for expensive chemical fertilizers. We now know that at least 17 genes are

involved in the nitrogen fixation system. We still do not know if the manipulation of such large numbers of genes will be possible.

Wetland rice is quite suitable for biological nitrogen fixation. Nitrogen is being fixed in wetland rice soils by biological agents such as blue-green algae, azolla water fern, and nitrogen-fixing bacteria.

Soil inoculation with blue-green algae is widely used in Egypt, India, and Burma. Preparation of inoculum is a well-developed small-scale village biotechnology. Yet, little is known about the actual mechanism of rice yield increase due to blue-green algae inoculation. This is an urgent area of research.

Recently, the potential of the azolla fern as a nitrogen-fixing crop suitable to rice culture has been recognized by many researchers. If we could cross azolla species, the improvement of strains would be much promoted.

None of these nitrogen-fixing systems can become the sole source of nitrogen in rice cultivation. Combinations of possible sources should be used depending on local environmental, cultural, and social conditions. For example, azolla is more suitable to double cropping of rice in irrigated areas than in rainfed areas. In contrast, blue-green algae can be easily used in rainfed areas.

Scientists at IRRI believe that the strengthening of existing systems of interaction between nitrogen-fixing bacteria and rice roots would be the most feasible way to increase nitrogen fixation of rice and thereby enhance production. As the living root is inhabited

by tens of millions of bacteria, genetic engineering techniques would be worthy of attempt.

Tissue culture techniques can also help to standardize breeding of perennial plants such as coconut, rubber, and quick-yielding fuel trees. Coconut palms, for example, suffer from diseases of unknown causes such as *cadang-cadang* in the Philippines and root wilt in India. But in the midst of severely infested plantations, healthy, high-yielding palms also occur. The propagation of these disease-resistant and high-yielding palms through tissue culture would be of particular value.

BANKING BRAINS

So far, institutions like the World Bank and the Asian Development Bank have been established to render financial support to worthwhile development projects. We now need to think about the organization of "brain banks" to provide countries with objective and up-to-date advice on technology choice and transfer. This has become particularly urgent because of the growing commercialization of skills and know-how, and the growing secrecy surrounding discoveries.

To be successful, the brain banks will obviously need the support and guidance of leading scientists and technologists who are not only authorities in their respective fields of specialization, but are also humanists.

Institutions in developing and developed countries can also enter into twinning arrangements to maximize the benefit from their complementary strengths.

Likewise, individual scientists can collaborate on projects of mutual interest. Simplified administrative procedures and appropriate financial support mechanisms will be needed, however, to foster such collaboration.

Periodically, seminars should also be held for policymakers and political leaders to familiarize them with new developments in biotechnology and help them to make investment decisions.

Several ideas, including the setting up of international and regional centres, are now being considered by the UN and other organizations. Immediately, a modified version of the TOKTEN scheme (Transfer Of Know-how Through Expatriate Nationals, in which scientists, engineers and other specialists working abroad are invited to return to their home countries) will be useful. The TOKTEN scheme needs to be broad-based in fields such as biotechnology, so as to perhaps include not only expatriate nationals but also other appropriate experts.

The opportunities now available for integrating emerging and traditional technologies in fields such as biotechnology, microelectronics, computer science, and satellite imagery and communication need to be explored. It is through the planned and purposeful integration of the old and the new that we can sow the seeds for sustainable development. □

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