Biotechnology and Nutrition

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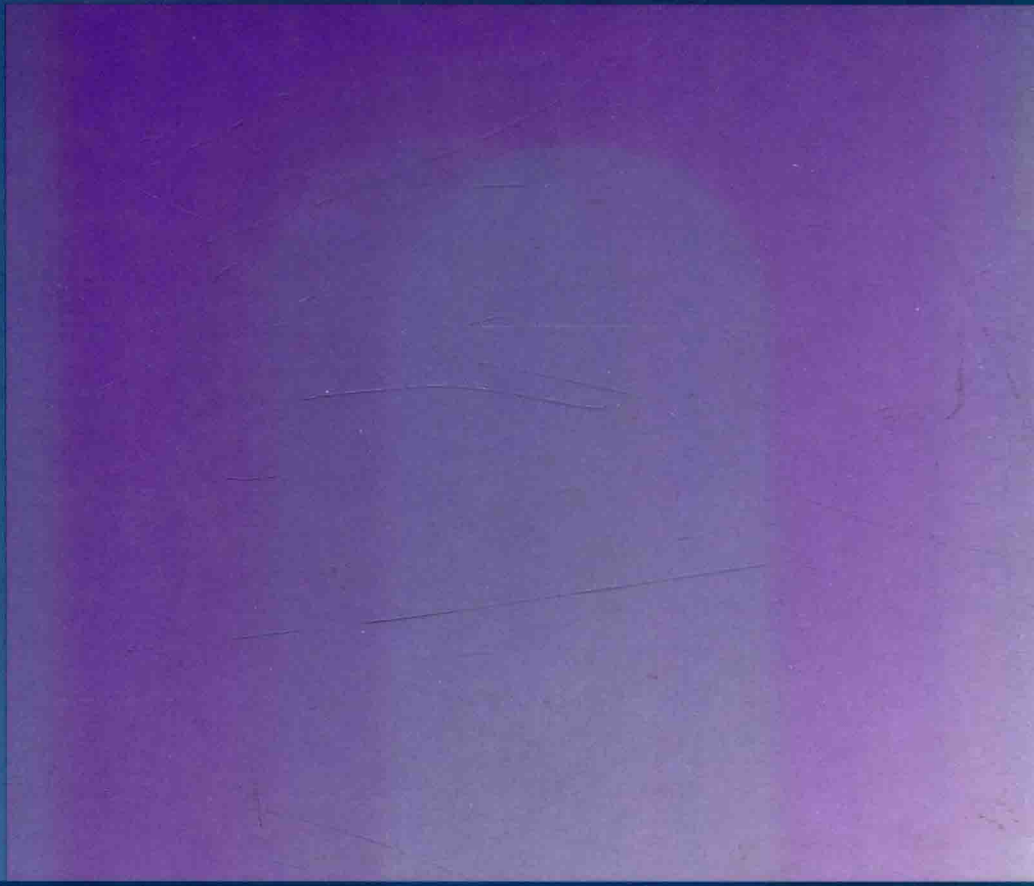

UM / USDA / DUPONT

Biotechnology and Nutrition

PROCEEDINGS OF THE
THIRD INTERNATIONAL SYMPOSIUM

Jointly Sponsored by:
The University of Maryland,
The United States Department of Agriculture
and E. I. du Pont de Nemours & Co.

Butterworth–Heinemann
Boston London Oxford Singapore Sydney Toronto Wellington

ISBN 0-7506-9259-6
Library of Congress Catalog Card Number 91-077736

Butterworth-Heinemann
80 Montvale Avenue
Stoneham, MA 02180

10 9 8 7 6 5 4 3 2 1

Printed in the United States of America

PREFACE

Genetic manipulation will lead to plants and animals that resist diseases, pests, and stresses, require less fertilizer or feed, and yield more food and fiber. These changes will increase the availability of agricultural products while decreasing their cost. These are important goals, but they are not new goals. Classical breeding and selection already have made great progress along these lines.

More exciting, and probably of greater ultimate consequence, is the use of biotechnology to alter the chemical composition of plants and animals to improve the nutritional value of food obtained from them. Transferring genetic material between species can provide characteristics difficult or impossible to obtain through classical breeding. Improving nutrition is a goal in developed countries, but it is even more important to the developing countries. In the mid-term, the most important contribution of biotechnology to nutrition in developing countries will be improved yields of food crops. In the long-term, however, improvement of nutritional quality may be more significant. For example, adequate protein, with a balanced composition of essential amino acids, is lacking in diets in most developing countries. Conventional plant breeding techniques have produced some new varieties with a better profile of amino acids; biotechnology can accomplish such improvements more rapidly.

One of the great challenges will be to decide what compositional changes of crop plants and meat animals are desirable from a nutritional standpoint. In many cases, the basic information needed to make sound decisions is lacking. For example, the nutritional influence of dietary fatty acids of various chain-lengths and degrees of saturation remains incompletely understood. Without adequate knowledge, changing the composition of nutrients in food could result in poorer nutrition instead of better nutrition. For example, while it might be possible to mimic the fatty acid composition of fish in many other foods, to do so on a widespread basis may not make sense—consumption of 20 g or more per day of fish oil can cause physiological harm. Furthermore, the highly unsaturated fatty acids of fish are subject to rapid autoxidation with accompanying

off-flavors, loss of nutritional value, and generation of toxic products. To impart the fatty acid composition of fish to other foods also would impart the delicate, perishable nature of fish to those foods.

In considering compositional changes, there is no reason to try to make every food nutritionally complete in itself. In fact, enhancing the vitamin and mineral content of every food would be undesirable, because some vitamins and minerals are toxic when consumed at high levels. Precedents for making such decisions exist in the rationales that were used to support the fortification of a few foods, such as milk and bread, with vitamins.

In this volume, the authors explore a number of areas related to biotechnology and nutrition. They begin with the broad consideration of human nutrition and the ability of biotechnology to improve nutrition. Specific subjects appear under the headings of Carbohydrates, Proteins, Vitamins and Minerals, and Edible Oils.

Biotechnology will improve the nutritional quality of foods, but the full realization of its potential will require the participation of scientists with many backgrounds. In organizing this symposium, our intent was to provide a forum for nutritionists, molecular biologists, animal and plant biochemists, food scientists, policymakers, and others who will influence the improvement of nutrition through the application of biotechnology. We also wanted to bring together scientists from universities, government, and industry. We believe that our intentions were fulfilled, and most of the credit must be given to the excellent speakers who shared their diverse knowledge and experience with us and, now, with you the reader. The remainder of the credit must be divided between the Program Committee, which used such excellent judgment in assembling a panel of such well-qualified speakers, and the Arrangements Committee, which provided such a favorable environment for our symposium.

We are indebted to the University of Maryland, the Agricultural Research Service of the USDA, and the du Pont Company, who sponsored the symposium and provided financial support and other services that made the Third International Symposium on Biotechnology and Nutrition a success. The symposium provides a continuing example of a successful and mutually beneficial cooperation between a public university, a governmental agency, and private industry.

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Acknowledgment

We gratefully acknowledge the efforts of the members of the Program Committee and the Local Arrangements Committee. Special appreciation is due to Dr. Anthony Kotula, who chaired the Program Committee and to Mrs. Helen Phillips, who chaired the Local Arrangements Committee.

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The new tools of biotechnology will have a broad and diverse impact on world agriculture and human nutrition. For industrialized countries, biotechnology may provide solutions to food safety problems, as well as lead to improved nutritional qualities of some agricultural products. It may also lead to the development of new products with unique nutritional qualities. In the medium-term, the most important contribution of biotechnology for developing countries will be continued improvement of the yields of basic food crops. Improved nutritional qualities of traditional crops also hold great promise for combatting malnutrition, but these applications are likely to take longer to develop. Special efforts in research, training, and technology transfer will be necessary if the developing world is to fully benefit from the new products of agricultural biotechnology.

Introduction

The new tools of biotechnology will have a broad and diverse impact on world agriculture and human nutrition. For centuries, people have sought to improve plants, animals and microorganisms to produce food and fiber for their own needs. The process of genetic improvement is the backbone of agriculture, and the crux of our ability to feed the growing world population.

The recent discoveries of biotechnology offer a powerful yet precise set of new tools to use in this endeavor. We are only beginning to explore the diverse applications of these tools. Indeed, biotechnology may one day have a greater impact on our lives than any of the other revolutionary technological advances of the 20th century.

The world needs more and better food. This is a simple and yet easily forgotten fact. It is estimated that 75 million people are malnourished—75,000 people die each day from the effects of malnutrition and related diseases. And, because of continued population growth, this depressing picture will grow even more gloomy, if we do not increase agricultural productivity.

According to the Consultative Group on International Agricultural Research, world cereal yields must increase 35 to 40 percent in the next decade just to keep hunger and malnutrition from getting worse. If we expect to make headway, then we need to do better than 40 percent.

Biotechnology offers one of our best hopes of meeting this challenge. The diversity of topics being presented at this Third International Symposium on Biotechnology and Nutrition is evidence of the breadth of direct applications of biotechnology to food safety, food production, processing and digestion of food by man and animal. Research on molecular approaches to carbohydrate modification, amelioration of protein, enhancement of vitamins and minerals and modification and production of edible oils offers important opportunities to improve our food supply and to tailor products to meet specialized nutritional needs, and food preferences.

Also of great importance to improving the nutritional status of the world's people is what biotechnology can do to increase the quantity of food being produced, especially in the Third World. In this regard biotechnology may be a key technology for increasing yields of basic food crops and decreasing post-harvest losses, a critical problem in developing countries.

These improvements will not come about without concerted efforts to translate the potential of biotechnology into reality. If we are to fully benefit from biotechnology, the United States and other industrialized countries must set the tone by dealing effectively with two key issues—regulatory policy and consumer acceptance.

As a leader in the development of biotechnology, the United States, scientific community must actively communicate with the public and inform them about both the benefits and the risks associated with biotechnology. We also must develop systems of oversight that are as coherent and transparent as possible, so that the public gains confidence in the processes that we are using to ensure their safety and protect the environment. But equally important is developing systems of oversight based on risk, which do not overburden the research community with regulatory requirements in areas we already know are safe.

This is a difficult balance to achieve. If we are successful in achieving this balance in the United States, biotechnology will flourish, and this should help policy-makers in other countries pursue a similar path.

In addition to achieving the general prerequisites of consumer acceptance and sound regulatory policy, we must also be sure that we devote adequate resources to supporting the science base upon which biotechnology is being built. While it is true that much of the research supporting product development is being done in the private sector, continued success will not be possible if we do not strengthen public research. The needs in this area can be summed up rather succinctly—more and better trained people, new types of research institutions, and, of course, increased funding.

In addition, there is a need to make special efforts to ensure the application of biotechnology to the developing world. These efforts may involve increased funding for national and international research centers, creating international networks of researchers to address certain commodities which are not commercially important to the industrialized world, and stepping up training for developing countries' scientists and technicians.

Benefits to the Consumer

During the next three days you will be hearing many impressive examples of how biotechnology is being applied to improve the food supply and insure food safety; thus it would be redundant for me to go over these now. What I would like to emphasize is that many of the areas being addressed offer direct benefits to consumers. This is good news for agricultural biotechnology, since one problem to date in trying to communicate with the public has been that products which benefit consumers directly have been slow to emerge from the research and development pipeline.

Biotechnology products which offer nutritional advantages should appeal to consumers, both here and abroad. According to the National Research Council's report, *Designing Foods*, recent public opinion surveys show a growing trend toward consumer interest in the nutritional composition of food and the diet as a whole. Two-thirds of consumers indicated they had recently decided to alter their diets by making such changes as reducing salt, sugar or fat intake, or increasing consumption of foods which contain fiber, or calcium.

Of course, consumer attitudes studies do not always coincide with real consumer behavior. Indeed new high-calorie, high-fat foods such as gourmet ice cream bars, frozen french toast and pancakes and potato chips are selling better than ever. This paradox has led the National Research Council to hypothesize that in the United States we are seeing the emergence of a new philosophy of nutrition: that a balanced diet can be achieved from a variety of foods—high-fat as well as low-fat—consumed over several days or even a week, compared with the more traditional thinking of three square meals a day.

In addition, consumers are demanding that food be free of additives and residues, exciting, palatable, appetizing, available all year round, move from supermarket shelf to stomach in record time, and be entirely "natural."

Public education programs are to prevent misinformation about nutrition and food safety. However, in areas where real nutritional needs exist, or where there are food safety problems to be solved, biotechnology can be part of the solution.

Producing More Food

But improving food and making it safer are not enough. The world needs to increase agricultural production as well. For the past few decades we in the industrialized world have been shielded from the reality of the increasing world demand for food and fiber because of the success we have enjoyed in our domestic agricultural production. One might say our vision has been blocked by warehouses of butter and cheese and silos overflowing with wheat.

Some Western European nations are even cutting back on research which would increase the efficiency of food production, because they believe they simply don't need more food. Such policies are shortsighted. As Eastern Europe moves to a market economy demand for high quality food and fiber products, our capacities to produce them may be outstripped. World wheat reserves are at the lowest point in years, and in 1989 and 1990, the United States experienced a fluid milk deficit in some regions of the country.

Developing countries must dramatically increase their food production just to keep pace with population growth. The most promising approach may be to apply biotechnology to increase yields of basic food crops. For example, *in vitro* culture for rapid multiplication of disease free planting materials is now a well understood, yet

labor-intensive technique. According to a recent FAO report, China already uses this approach to produce about 250,000 hectares of virus-free potato seedlings each year or about 10 percent of all potato production in the country. Using *in vitro* culture has allowed the Chinese to increase potato yields by as much as 150 percent in recent years.

An international network of scientists which stretches from Africa to Europe to the Americas is striving to apply the newest techniques of biotechnology to cassava. Cassava is a basic staple in much of the world which has proved difficult to improve using conventional techniques. One goal of the research network is to increase the protein content of the plant. This could be extremely helpful in fighting protein malnutrition in Africa and elsewhere. In addition, the researchers are striving to produce cultivars resistant to viral diseases and pests which often plague cassava production in Africa and Latin America. They are also trying to improve stress tolerance to make cassava more drought resistant.

The Rockefeller Institute is supporting an international effort to apply biotechnology to improve rice yields. The International Rice Research Institute (IRRI) in the Philippines is spearheading this effort by creating an interdisciplinary team of scientists to work on transforming rice. Beyond improving yields, scientists in Pakistan and the Philippines are working on introducing nitrogen fixation genes into rice. If this breakthrough occurs, it could dramatically reduce the need for fertilizer in many developing countries.

Another strategy which may assist in meeting the nutritional requirements of the third world is using biotechnology to help reduce post harvest losses. Some estimates are that as much as fifty percent of food produced in developing countries is lost during storage, transport, and preparation.

One example of how biotechnology may assist is "anti-sense" technology being developed by firms in Europe and the United States. Simply by reversing a piece of RNA, the researchers have been able to block the creation of an enzyme which causes tomatoes to spoil. Thus, the antisense tomato can stay ripe at room temperature without getting soft and mushy. This technology may be widely applicable to fruits and vegetables and a real boon to developing countries where refrigeration is largely unavailable.

These are but a few examples of the application of biotechnology to improving the nutrition of the world's poor. There are many other examples. Yet, critics of biotechnology say that such an optimistic appraisal is naive. They point to the "green revolution" which some

contend was over-sold as a solution to Third World problems. Some observers even go so far as to say that most technologies which Third World countries adopt from the industrialized world only exacerbate the differences between the haves and the have-nots.

Although I agree that it would be naive to portray biotechnology alone as an answer to developing countries' food problems, it should be pointed out that biotechnology has characteristics which make it especially promising for Third World conditions.

For example, it may actually reduce the amount of inputs needed to produce food crops. Varieties with built-in resistance to insects and diseases will obviate the need for some agricultural chemicals. If breakthroughs occur in transferring nitrogen fixation genes to cereals, fertilizer requirements would also be reduced.

Biotechnology is a broad set of techniques applicable to many species with the potential to affect practically every agro-climatic zone from the Amazon to the Sahel. Although the first plant species was transformed less than ten years ago, over 50 plant species have now been modified. New techniques such as microinjection have overcome earlier barriers. The range of these new techniques is extremely broad, as is the range of genes which may prove useful.

Biotechnology is size-neutral. Because we can incorporate improvements in the seed, small farmers will benefit as well as large farmers. In addition, farmers will not have to learn to grow new crops or drastically change their practices in order to reap these benefits.

Lastly, biotechnology fits into agricultural systems which are sustainable and conserve soil and water. Current work with genetically modified rhizobia may lead to environmentally sound methods of improving soil fertility. The goals of modifying crops to increase their tolerance to drought and salinity are also seeming more and more attainable. These traits are controlled by more than one gene, but researchers have recently reported that they have successfully transformed plants with as many as five genes at once.

The Policy Context

Technologically, the future seems bright. But as I indicated earlier, the promise of biotechnology to improve our food supply will not become reality, unless the countries which are biotechnology leaders come to grips with two crucial issues—public acceptance and regulatory policy.