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UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

Food Biotechnology

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BREI

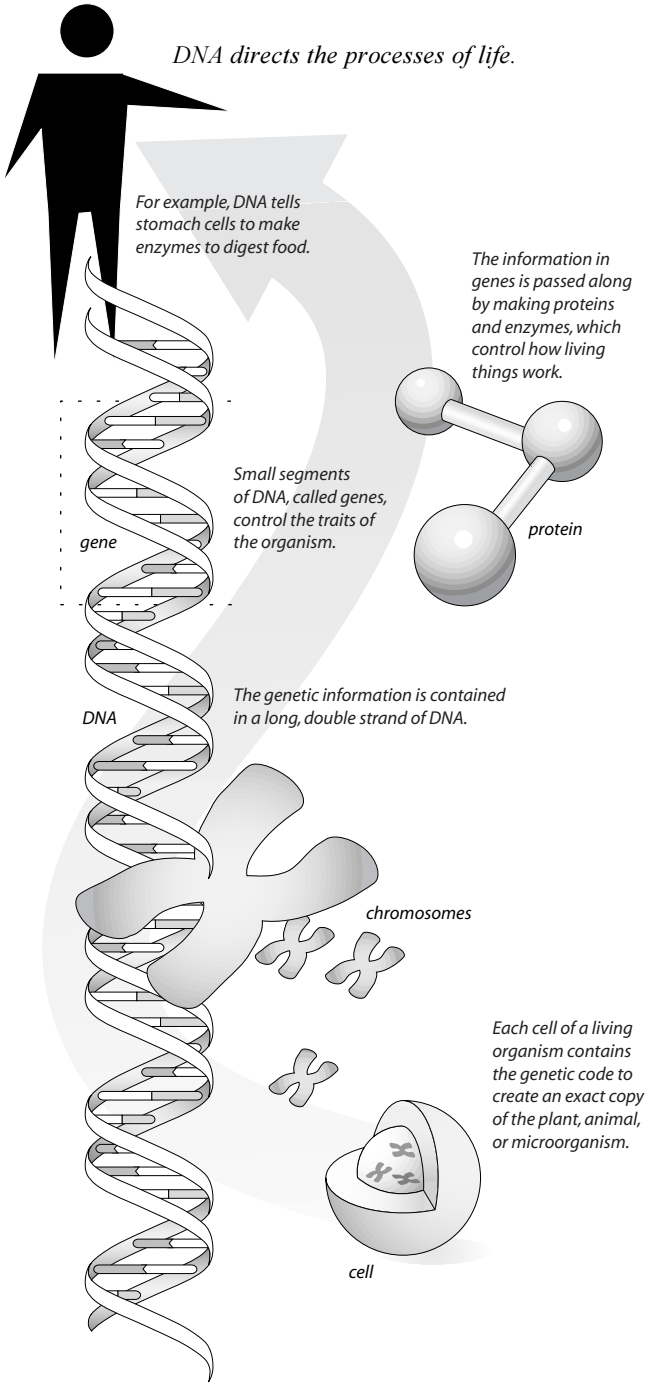
This publication is part of a series that seeks to provide science-based information about discoveries in agricultural biotechnology. The information in these publications comes from the Biotechnology Research and Education Initiative (BREI) committee, which is comprised of a multi-disciplinary team of research, extension, and teaching professionals from the College of Agriculture. The series is designed to help Kentuckians understand and assess the risks and benefits of agricultural biotechnology.

Some people use the term **biotechnology** to refer to the tools of **genetic engineering** that have been developed since 1973. But biology, technology, and human-directed genetic change have been a part of agriculture since the beginning of cultivated crops some 10,000 years ago. Biotechnology has, in a general sense, been used as a tool for food production since the first breeders decided to selectively plant or breed only the best kinds of corn or cows. Technology is a tool we use to achieve a goal, such as improved food quality.

Scientific advances through the years have relied on the development of new tools to improve health care, agricultural production, and environmental protection. Individuals, consumers, policymakers, and scientists must ultimately decide if the benefits of biotechnology are greater than the risks associated with this new approach. This publication provides information about biotechnology with examples of how these new tools of biology and agriculture are used in food production. It includes a perspective showing how biotechnology fits into the history and future of science and food. Its purpose is to educate consumers about food biotechnology so that they can make informed choices.

The technology tools used in biology have changed rapidly since scientists moved the first specific **gene** from one organism to another in 1973. This new era began in 1953 when scientists James Watson and Francis Crick determined the structure of **DNA**. DNA is the chemical language that determines the features and characteristics of all living organisms: plants, animals, and microorganisms. Once scientists understood how DNA was put together, they could determine which parts of the DNA (genes) are responsible for certain **traits**.

Genes determine traits by controlling the production of **proteins**, including **enzymes**. Proteins and enzymes are used by all living organisms to grow, metabolize energy, and become what their **genetic code** dictates. Each



cell of an organism contains the entire genetic code needed to create the organism. The interaction of genetic makeup and environmental factors shapes the nature of all living things. When people eat a "healthy" diet, they are controlling environmental factors that will, within the limits of their genetic makeup, decrease their risk of developing a disease.

From Breeders to Gene Jockeys

Plant breeders have for many years used tools and techniques such as selective hybridization grafting and cell isolation to improve crop quality and yield. And these early agricultural scientists made great advances, producing juicy ears of corn instead of hard-kerneled corn, which must be ground into flour, and present-day kiwi fruits rather than the hard berry from which they were developed.

Scientists using the relatively new tools of biotechnology have been called "gene jockeys" because of the great degree of speed and control with which they can change the inherited traits of plants, animals, and microorganisms. Today scientists can identify the gene(s) responsible for specific characteristics, such as disease resistance or nutrient composition, and insert them into another organism. What once took decades now takes years and can be accomplished with greater accuracy.

One of the most striking differences between traditional breeding and the genetic engineering approach is that the source of genetic material need not come from the same species. This allows scientists to exchange genetic information between bacteria, plants, and animals (including humans). These new techniques have prompted considerable debate on the ethical and moral aspects of this branch of science. All living organisms share the same genetic language. In fact, you probably share about half of your genetic information with a tomato plant. And the genetic information from that tomato plant can function in a corn plant. New techniques even allow scientists to decide in which part of the plant tissue a trait should be expressed, such as the pulp versus the skin of an apple.

When considering the risks associated with these new tools of food production, consumers need to understand how these tools differ from traditional agricultural methods. With traditional breeding methods, for example, increased levels of naturally occurring toxins may result from cross breeding designed to improve a crop. Breeders spend years "back-crossing" to rid the new plant of the undesired feature while maintaining the benefits of the hybrid. There are also risks associated with the current standard use of chemicals to allow crops to tolerate insects, infections, and adverse weather conditions.

The word biotechnology comes from the two words biology and technology. **Biology** is the knowledge and study of living organisms and vital processes. **Technology** is an applied science and a scientific method for achieving a practical purpose.

Plant Foods

When working with plant foods, scientists seek to improve foods for the benefit of consumers, producers, or the environment. Consumers may benefit from improved nutrition or food quality. Producers may be able to grow crops under adverse conditions, such as drought. Some genetically engineered plant foods require significantly fewer chemical applications during growth and therefore have less environmental impact.

Scientists use their current knowledge of plant biology to help them decide how to improve plant traits for foods. In the case of the slow-ripening Flavr Savr™ tomato introduced in 1994 by Calgene Inc., which was one of the first food plants produced using the tools of biotechnology, scientists knew that a type of protein called an enzyme causes tomatoes to soften as they ripen. When they isolated the gene responsible for the softening enzyme and inserted it *backwards* into the tomato's genetic code, the resulting tomato maintained good eating quality for a longer time than regular tomatoes. This technique allows better-tasting tomatoes to be grown and shipped to distant markets.

In 1986, a herbicide-resistant soybean was created using the tools of biotechnology. After several years of tests and studies, the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA) granted approval in 1994. The Environmental Protection Agency (EPA) granted approval in 1995, and the new soybeans were grown commercially in 1996. Given the widespread use of soybean products as food ingredients, it has been estimated that most U.S. food consumers in the year 2000 have eaten foods produced through genetic engineering.

In 1997, 18 crop applications were approved by the U.S. agencies responsible for regulating biotechnology. An estimated 35 percent of the 1999 U.S. corn and 55 percent of the soybean crop were grown from genetically modified seeds.

Animal Foods

The first FDA-approved application of biotechnology for production of food animals was to modify a microor-

ganism to make a hormone needed for milk production in dairy cows. This **genetically modified organism** (GMO) is a bacteria that can produce large quantities of the hormone for injection into dairy cows. An estimated one-third of U.S. milk is produced using the GMO-produced hormone, which increases milk production by 10 to 25 percent. Another GMO is used to produce about 75 percent of U.S. cheese by providing a necessary enzyme formerly harvested from the stomach lining of cows.

In addition to the use of GMOs in animal food production, biotechnology can be used to create **transgenic** animals. But developments of this biotechnology application may be slow due to the generally greater difficulties in animal genetic engineering and to the social and ethical concerns of consumers about the animal food applications of biotechnology. Nevertheless, some genetically modified food animals are under consideration for approval and marketing. An example is a salmon that grows to a marketable size more rapidly than regular salmon. Most transgenic animal research is for medical applications, as in the case of the cloned sheep "Dolly," where scientists are investigating cystic fibrosis disease.

What Consumers Need to Know

Each day consumers decide whether the perceived benefit of an action is worth the risk associated with that action. If an individual perceives the benefit to be worth the risk, the activity is deemed to be "safe." In order to make responsible decisions about these issues, consumers, scientists, and government agencies need to be informed. Risk assessment studies about the impact of biotechnology have been and are currently being conducted to assess the impact of biotechnology, just as they are for any other new medical or agricultural technology.

How these foods are regulated

Foods produced with the new tools of biotechnology are required to meet the same requirements set forth by the FDA for all foods. The FDA has issued the following guidelines to ensure the safety of foods developed using biotechnology:

- Genetically modified food products will be regulated just as traditionally produced foods are regulated.
- The products will be judged on their food safety and nutrition characteristics, not by the methods used to produce them.
- Any new ingredients will be regulated on the basis of the potential benefits and risks of including them in the food supply, just as traditional ingredients, like food additives, are regulated.

Special labeling for genetically modified foods is not required unless the potential for food allergy, nutrient composition, or product identity has been changed significantly. In the United States, consumers can purchase organic foods that, by definition, do not contain GMOs.

Other U.S. agencies charged with regulating the use of biotechnology are the EPA, which regulates substances with potential environmental impact, and the USDA. Some of the products of plant biotechnology have built-in pesticides, and the EPA is charged with regulation of these products. Several USDA agencies are involved, including the Animal and Plant Health Inspection Service, the Food Safety Inspection Service, the Agricultural Research Service, the Economic Research Service, and the Cooperative State Research, Education, and Extension Service. To learn more about the USDA's role in biotechnology, visit <http://www.aphis.usda.gov/biotechnology>.

The benefits and risks of biotech foods

What benefits can consumers expect from food applications of biotechnology in the future? Consumers will have the choice of foods enhanced with extra nutrients, such as vitamin-enhanced rice. A higher-starch potato could be used to make lower-fat french fries and potato chips. The altered starch content results in potatoes that absorb less oil in the frying process. New vegetable oils have been produced that have significant health benefits to reduce the risk of cancer and heart disease. Biotechnology may someday yield peanuts with a lower potential for allergic response. Food crops with built-in insect, disease, and herbicide resistance can be produced using fewer chemicals. Ideas for new foods created through biotechnology will be identified and tested for many decades to come as we learn about the possibilities and limitations of this new tool.

What are the risks associated with the use of biotechnology for food production? There are two issues of primary concern to food consumers: (1) the potential introduction of food allergens and (2) marker genes that would increase human resistance to antibiotics. The potential for food allergens in biotechnology products is monitored by the FDA. Each food is evaluated for its allergenic potential as part of the regulatory process and labeling is required if a known allergen is transferred to a food source not normally associated with that allergen. Presently, no food products are on the U.S. market with this designation. In fact, some products have been pulled from the review process precisely because of this concern. There is no current scientific evidence of increased antibiotic resistance as a result of genetically modified foods. (This would be more likely to result from overuse of prescription antibiotics.) However, because of public concern, crops are now being developed without such antibiotic-resistant genes.

Additionally, people are concerned about the environment and the introduction of "super" weeds or plants that are herbicide resistant or harmful to insects. Scientists are collecting data about both of these issues as part of their work to carefully assess the risks associated with the use of biotechnology. The EPA monitors the environmental impact of biotechnology, including its use for food production.

What Consumers Think about Biotechnology and Foods

Both the public and scientific communities are evaluating their stance on the use of biotechnology for food production. Most consumers favor the use of biotechnology when it allows producers to decrease their use of agricultural chemicals. Biotechnology is less of a concern to U.S. and Kentucky food consumers than other food-related risks such as fat, cholesterol, germs, or pesticides. Ultimately, consumer desires will decide the fate of foods produced with biotechnology through the effect of demand on supply and their demand for accountability from U.S. public agencies. For consumers to responsibly participate in these decisions, they must be well informed about the potential benefits and risks associated with biotechnology.

Glossary

Biotechnology: applied biological science.

DNA (DeoxyriboNucleic Acid): the chemical basis for the genetic code, DNA is a long strand of four basic chemical units; small segments of DNA code for genes, which control traits.

Enzyme: a protein that helps biological reactions occur; for example, enzymes help the body convert food into energy.

Gene: a small part of a DNA strand that contains information about how an organism will develop or which traits the organism will inherit; for example, white versus yellow corn.

Genetic code: the DNA sequence that provides the "blueprint" for cells and organisms.

Genetic engineering: in a broad sense, all genetic improvement procedures including plant and animal breeding; more specifically, genetic improvement using modern techniques to work with DNA.

Protein: the primary product of genetic code, necessary for life processes in all plants and animals.

Trait: a characteristic that distinguishes one plant or animal from another; for example, white versus yellow corn.

Transgenic: a plant or animal with an altered genetic makeup resulting from genetic engineering.

For more information about biotechnology, visit the University of Kentucky Biotechnology and Research Education Initiative Web page at <http://www.ca.uky.edu/brei/>. This resource contains facts and information on various aspects of biotechnology and links to other resources.

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