



Biotechnology in Our Food System

Frequently Asked Questions and Answers

Valerie L. Vantreesse, Department of Agricultural Economics



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.

Pick up a newspaper or turn on the radio, and chances are you will hear biotechnology mentioned. Just what is biotech? Have you ever eaten genetically engineered food? How will biotechnology affect the environment? Below you will find answers to some of the questions people have about biotechnology in our food system.

What is biotechnology?

Biotechnology is the application of scientific information and methods to biological problems found in agriculture and medicine. It includes moving traits or characteristics from one organism to another to improve or create new industrial, medical, and agricultural products. Because it integrates knowledge about biology and genetic engineering, biotechnology has many diverse applications—from making pharmaceutical drugs (such as the production of insulin since 1982) to producing ethanol from corn. Agricultural biotechnology allows us to more precisely develop plants, animals, and microorganisms with specific characteristics, such as a higher protein content or reduced incidence of *E. coli*.

What are GMOs?

Genetically Modified Organisms are those living things whose genetic makeup has been altered or modified through biotechnology processes.

How does agricultural biotechnology differ from conventional breeding?

Both biotechnology and conventional breeding share the same goal of increasing the desirable characteristics of a plant or animal, such as increasing the nutritional value of rice or developing a higher protein content in sheep's milk. However, biotechnology is much more precise in that it carefully selects a specific gene or trait in one living organism and transfers only that gene to another organism.

Conventional breeding, on the other hand, pools all the characteristics of both parents, with the hope of finding the desired trait in the new genetic lines. For example, scientists may breed a high-yielding corn variety with a faster-maturing variety. In fact, essentially all foods are derived from living things that

have been previously genetically modified through conventional breeding. Both processes result in genetic modification, but agricultural biotechnology is a much more precise and expedient means of producing the desired characteristic in a plant or animal.

Another difference between biotechnology and conventional breeding is that biotech allows scientists to transfer genes across species, including from animals to plants and vice versa, which conventional breeding cannot normally achieve. While this remains a more controversial aspect of biotechnology, sharing genetic information across species has proven quite valuable, such as in the production of rennet (used in cheese production) and interferon (used in combating cancer).

How can biotechnology reduce production risks for the farmer?

Farmers face many different kinds of production risks, such as insect and disease infestations, weather-related calamities such as drought, and insufficient soil fertility. By using plants improved by genetic modification, farmers can reduce the risks of these and other problems that reduce their yields or destroy their crops. Most notably, plant scientists have produced seed varieties that have given the plants a natural form of protection from certain insect pests such as corn borers (for corn), Colorado potato beetle and tobacco budworm (potatoes), and the boll weevil (cotton). These genetically modified varieties include what is referred to as Bt corn, Bt potatoes, and Bt cotton, named for *bacillus thuringiensis*, a bacterium that occurs naturally in the soil.

Plant geneticists have also produced herbicide-tolerant soybeans and corn, allowing farmers to reduce chemical use. By planting seed varieties that can protect themselves against plant pests, farmers are able to reduce the amount of herbicides and insecticides they use.

Bioengineered crop seeds give farmers the opportunity to make yields less variable. And some of the bioengineered crops being developed may have higher yields than their conventional counterparts.

Plant scientists have also been able to engineer plants that are less susceptible to drought and that absorb nutrients from

the soil more efficiently. These advances may prove particularly valuable in many developing countries that suffer greatly from inadequate rainfall, erosion, and soil infertility, such as those found in sub-Saharan Africa.

Does that mean biotechnology is good for the environment?

Advances in biotechnology have enabled some plants to develop their own resistance to certain diseases, insects, and chemicals. For example, Roundup-Ready® corn and soybeans are resistant to the herbicide Roundup®, allowing the farmer more leeway in the timing of herbicide applications and simplified weed control. Growing genetically modified crops that have built-in resistance to certain kinds of diseases (such as potato blight) can also reduce chemical applications.

Consequently, farmers can significantly reduce the amount of pesticides and/or use more environmentally friendly pesticides than they typically use on some crops if they plant certain kinds of genetically modified seed. Obviously, the fewer and/or more environmentally compatible herbicides and insecticides we use on agricultural crops, the better it is for our soil, air, and water quality. Other newly developed GM crops require less cultivation, thereby reducing soil erosion and fuel usage.

Can agricultural biotechnology harm the environment?

There are some concerns that new genetically modified crops can be harmful to the environment. For example, Roundup-Ready corn and soybeans are only resistant to the herbicide Roundup (and not to other herbicides). Environmentalists assert that scientists do not have enough data to fully understand the long-term impacts of GM crops on the environment, and they believe that more research is needed before we release these crops into the environment. Other environmentalists argue that Roundup-Ready seeds will only encourage the use of Roundup when food should be produced organically without pesticides.

There is also concern that genetically engineered crops may interfere with the ecosystem. Lab experiments have tried to evaluate the effect of Bt corn pollen on monarch and swallowtail butterflies and the impact on rats fed experimental biotech potatoes. Although conclusions are mixed, the general consensus is that animals and insects would have to consume extremely large quantities of biotech crops before any adverse impact could be detected. Field studies have shown little or no harm and generally much less adverse effect on nontarget organisms than from conventional pest control.

What about the development of “super weeds” or “super insects”?

The concern here is that the use of biotech crops that are resistant to certain weeds, insects, and diseases could facilitate the development of “super weeds” or “super insects.” This concern has always been present with conventional breeding practices and in the pharmaceutical industry (for example, as microbes have developed resistance to antibiotics).

Scientists are working to make sure that existing weeds and insects have a “place to go” so there is less pressure for them to naturally alter their own resistance to genetically modified crops. They have developed a refuge strategy in which farmers are instructed, for each biotech Bt crop, to plant a certain minimum acreage or “refugia” of conventional seed, where the susceptible pest population is maintained. Further, all biotech crops are subject to strict controls from the Environmental Protection Agency before being field-tested and again prior to commercial release.

Scientists and farmers are keenly aware of the concern over super weeds and insects and are carefully monitoring fields to manage the situation. Integrated Pest Management, including use of natural biological controls, becomes increasingly important as farmers increase their use of biotech crops and reduce their use of pesticides.

What about loss of biodiversity?

Many environmentalists, including farmers themselves, are very concerned about the impact of plant and animal breeding and the loss of genetic diversity in our food system. For example, the widespread use of artificial insemination has allowed four bulls to claim responsibility for nearly all two million cows in New Zealand! Although the increased adoption of conventionally bred crops has raised similar concerns, the earth’s pool of genetic diversity must be maintained for the future.

Scientists continue to work actively to preserve plant species by preserving genetic material (DNA) in lab facilities and field plots around the world. The science of biotechnology has dramatically increased our knowledge of how genes express themselves and has highlighted the importance of preserving genetic material.

Another concern is the narrow range of crops that farmers currently grow. There are only about 35 crops with significant world production. For example, if all farmers grew the same variety of corn, one unstoppable corn blight could easily destroy a huge amount of corn production. This has been a worry with conventionally bred crop varieties as well. Biotechnology can help in two ways. First, crop varieties can be developed through biotechnology that are “disaster-resistant” much more quickly than through conventional breeding. And biotechnology has the increased capability of developing multiple subspecies of the same crop, tailored to specific growing conditions and consumer needs, thereby reducing the chance of an entire crop being wiped out, as the corn blight of the 1970s nearly did with traditionally bred corn.

Does the use of biotech crops hurt other (nontarget) insects?

In reducing insect populations of one predator (such as the corn borer), farmers want to take care not to hurt or destroy other insect populations (what scientists call “nontarget species,” such as the monarch butterfly). When spraying traditional chemical insecticides, farmers risk destroying both target and nontarget species. But when corn is grown from genetically modified seeds (such as Bt corn), the plant has a natural resis-

tance to the corn borer and the corn borer only. Again, planting GM seed can help reduce pesticide use and the risks to nontarget species.

Are we already eating foods produced through biotechnology?

Many foods have been “genetically engineered” for hundreds of years, including bread made with yeast, wine through grape fermentation, and present-day corn, which was bred from North American maize.

In 1999, approximately 55 percent of all soybeans, 60 percent of cotton, and 36 percent of corn grown in the United States were derived from biotechnology (USDA). Other biotech crops include canola, rice, potatoes, strawberries, green peppers, and tomatoes. It is also estimated that 75 percent of all cheese is made using bioengineered rennet (rather than rennet derived from the lining of a cow’s stomach), and 80 percent of all processed foods in the U.S. contain some genetically modified food ingredients.

Are genetically engineered foods safe to eat?

Biotech foods are extensively researched and reviewed by three different federal government agencies: the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). Many individual state governments also work together to ensure that crops produced through biotechnology are safe. These foods must follow the same stringent rules as foods produced conventionally. It often takes 10 to 15 years for a biotech crop to get from the research laboratory to the grocery shelf.

Prior to field testing, companies and research institutions must register all biotech crops with the USDA for permission to field test them. Researchers must ensure that no pollen or plant parts of the tested plants are released into the environment.

Biotech crops must also pass the scrutiny of the EPA, the agency that has the authority to control all new pesticides, including genetically enhanced plants. The EPA is concerned with the impact on nontarget species and endangered or threatened species.

Finally, any foods derived from biotech crops must pass FDA inspection. Current law requires that biotech foods be labeled as such if their nutritional content or composition differs significantly from their conventional counterparts or if they pose any health risks. Both the National Academy of Sciences and the FDA have determined that, in general, biotech-derived foods are as safe as, or safer than, conventional counterparts.

If biotech foods are so safe, why don’t companies want to label them?

U.S. food companies do not want to alarm consumers into thinking that foods produced through biotechnology are fundamentally different from conventionally produced foods, let alone inferior or unsafe. Many companies fear that *any* labeling would be perceived by consumers as a warning or red flag against biotech-derived foods.

It may also be confusing to some consumers that food labels are not required to contain information on how the foods are produced. Instead, labels contain information on food ingredients and potential health concerns. Again, labeling is only required when the biotech-derived food product is significantly different from the conventional counterpart.

Further, it has become extremely difficult for food companies to verify whether the food components they use (for example, soybean oil or corn syrup solids) are derived from biotech crops or not. The composition of biotech food components may change from shipment to shipment, which, as food companies have argued, would make labeling of most processed foods a logistical nightmare and create a huge unnecessary expense.

But don’t we as consumers have a “right to know” if we are consuming biotech foods?

Many argue that consumers do have the right to know. Consumers are increasingly turning to organically produced foods just for that reason. By definition, certified organic foods cannot be derived from biotechnology-produced crops. But the lines become blurred as to what is a biotech product and what is not. If a cow was fed organically grown Bt corn, is the meat “organic”? By definition, no.

If most consumers are comfortable consuming biotech foods and are not willing to pay the higher costs associated with labeling them, should the food industry be forced to label biotech foods anyway? Some argue that anti-biotech consumers can simply purchase organic foods and that their concerns have no scientific basis. Others, arguing that biotech foods are too new to be safe and citing other products such as saccharin and DDT, oppose biotech foods on moral or religious grounds and demand that the industry respond to their needs.

Mandatory labeling not based on health or scientific considerations will make everyone pay extra for what only some want. Another solution for consumers who prefer such products might include voluntary labeling, such as is done for kosher foods.

Finally, biotechnology covers a wide array of processes and procedures. Genetic modifications can range from simply improving a natural corn gene in a way that can be considered more precise standard breeding to introducing animal genes into plants or bacterial genes into animals. Should all products be labeled the same?

I’m allergic to many food items, such as wheat and peanuts. How can I be sure that a food I am eating does not have any genes from those plants to which I am allergic?

Each food is evaluated for its allergenic potential as part of the regulatory process. Labeling is required if a known allergen is transferred to a food that doesn’t normally contain 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 and will not make it to the consumer market precisely because of this concern.

I just don't feel comfortable with biotechnology—it scares me. Is it morally and religiously right to share DNA across species?

It is very difficult to argue with a person's moral and ethical beliefs. For example, if the DNA from a pig were inserted into a corn plant, would those refraining from food that is not kosher have the "right to know"? We are already putting codfish genes into tomatoes to lengthen their shelf life and human genes into sheep for medical purposes. Although no currently marketed GM crop products contain animal (including fish) genes, what next? Many new technologies cause us to do some real soul-searching. These are important questions as we recognize the dangers and the beauties of technological advancement.

Bioethicists are working with scientists, policymakers, and concerned citizens trying to find common ground on how biotechnology is used in our lives. Biotechnology, like other technologies, is creating new moral and ethical dilemmas. The courts and regulatory environment are scrambling to keep pace with science.

How can biotechnology alleviate world hunger?

World population hit the six billion mark in the fall of 1999 and is expected to double in the first half of the next century. Although world agriculture has been able to increase food production faster than population growth, one-fourth of the world's population still suffers from hunger and malnutrition. Further, increased yield gains have come at a cost, as rainforest and wetland habitats have been destroyed, soil fertility has diminished in many parts of the world due to intensive cropping and grazing practices, and intensive use of agrochemicals has contaminated many of our ecosystems.

Through agricultural biotechnology, scientists are working to develop new higher-yielding crop varieties that will require fewer chemicals and less intensive cultivation, allowing farmers to produce more food and better food using fewer resources. However, weak or nonexistent intellectual property laws in many developing countries have severely limited the sale of GM seed varieties in those parts of the world. Unless biotech companies can protect their "investments" in genetically modified seed, sales will continue to be constrained. The role of the public sector, including nongovernmental organizations, is crucial in spreading the benefits of agrobiotechnology to the Third World where profit margins may be low or nonexistent.

A recent example of a private/public sector partnership in sharing the advances of agricultural biotechnology to developing countries is the recent announcement by Monsanto to provide royalty-free licenses of "golden rice" (genetically enhanced with Vitamin A). Golden rice was developed by two professors, Potrykus of Switzerland and Beyer of Germany, with generous support from the Rockefeller Foundation. At the same time, Monsanto opened its rice genome sequence database to aid researchers around the world in developing other new rice varieties. While some accepted this news with skepticism over

Monsanto's "real" motives, others applauded this as a beginning to future collaborations between the private and public sector in biotechnology research.

In addition to farm-level benefits, the improvement of nutritional quality in our food supply through biotechnology has begun to show great rewards. Biotechnology holds the promise of increased dietary micronutrient and mineral availability to many people in the developing world. But it is important to remember that access to food in developing countries is frequently a political matter, and technology cannot always solve political challenges.

What do you mean by the improvement of nutritional quality through biotechnology?

Agricultural biotechnology has allowed scientists to insert certain nutritional traits, including increased protein levels, vitamins and minerals, and healthier oils into crops with more precision and timeliness than conventional breeding. For example, new strains of rice have been developed that would help combat vitamin A deficiency (a leading cause of blindness) by delivering higher doses of beta carotene and iron. Other biotech foods on the horizon include potatoes that absorb less oil (which may reduce the incidence of heart disease) and the production of allergy-free peanuts and rice. Scientists are even developing a new variety of banana that could deliver vaccines against Hepatitis B and other deadly diseases.

How might biotechnology increase the market power held by large corporate farms and big agribusinesses?

Most of the biotech crops on the market today have required years and years of expensive scientific research and passage through a strict regulatory process. Consequently, most genetically engineered seeds are protected under patent and licensing restrictions to assist the companies in protecting their intellectual property.

For a biotechnology firm to develop and deliver a seed or other GMO to market, it must have a very large research, marketing, and distribution network. Right now, only the large, well-established agribusiness companies have networks extensive enough to achieve success in the commercial market. These conditions make it very difficult for smaller companies to compete with the large multinationals.

As fewer and fewer firms control more and more of the biotech industry, the market becomes more concentrated. A recent example is the acquisition of Pioneer Hi-Bred (the world's largest seed producer) by DuPont (a major agribusiness and agrochemical producer). The newly created Pharmacia Corporation is the result of a merger between Pharmacia & Upjohn and Monsanto Company. It has also been announced that Novartis (primarily a pharmaceutical company) plans on merging its agribusiness division with AstraZeneca to spin off a new company called Syngenta.

How does increased market concentration affect market performance?

To reduce the high costs of creating a GMO and getting it through the regulatory process into commercialized production, the large biotech companies increasingly have become vertically and horizontally integrated. While some agribusinesses are primarily *horizontally* integrated (such as John Deere, which produces basically one product—machinery—but for many different uses), other companies are increasingly *vertically* integrated (such as Perdue, which owns hatcheries, feedmills, production and breeder operations, and processing plants). In the global food system, large multinationals that are *both* horizontally and vertically integrated are becoming more commonplace, such as Philip Morris and ADM (Archer Daniel Midlands).

By taking on more and more of the marketing functions for more and more products, these large agribusinesses control much of the flow of moving products from the farm to the food table. From the consumer's perspective, all this integration in the food chain may lead to a more reliable food supply and lower food prices. On one hand, this market integration has increased the efficiency of the food system as reflected in low food prices that have remained constant over the last 20 years, after adjusting for inflation. Further, Americans spend less per person on food, relative to our incomes, than nearly anyone else in the world.

Proponents of this increased market concentration argue that these large multinationals have replaced open markets and competitive pricing, thereby increasing the risks of anti-competitive business practices. This type of market structure also makes it increasingly difficult for small farms to survive on low profit margins since they do not have the sales volume of the large companies. Many consumers are dismayed by the loss of the family farm and the rural countryside, blaming corporate farming for everything from hard tomatoes to steroid-pumped beef.

How will increased market concentration in the biotech industry affect farmers?

Agricultural biotechnology companies are also very integrated. That is, they buy research companies, farms, processing plants, transportation companies, and market outlets so they can own and control all the profits derived from the GMO. Some consumers are fearful that these large biotech companies will increasingly control our food supply, be totally driven by the profit motive, disregard environmental safeguards, and destroy the small family farm in the process.

Alternatively, biotech crops may allow farmers the opportunity to produce more specialized food crops that do not have the volumes of production needed to interest the large agribusiness. For example, organically grown Bt cotton or Bt sweet corn may appeal to a small but steady consumer base. The second wave of GMO crops with micronutrient or pharmaceutical properties may also provide profitable niche markets for small farms to fill.

In conclusion

Biotechnology holds many rewards for the world's agriculture and its people. But it also carries with it the responsibility of using that technology wisely to improve human health, protect environmental quality, and preserve farming as a way of life.

If you have any questions of your own, you may submit them to the Biotechnology Research and Education Initiative Web page at <www.ca.uky.edu/brei/>.

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