

Biotechnology: Answers to Common Questions

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We are entering the “Century of Biology.” Recent developments in the biological sciences are giving us a better understanding of the natural world. At the same time we are developing new tools that are collectively referred to as “biotechnology.” These help us address problems related to human health, food production, and the environment. Any new technology – particularly one as far-reaching as biotechnology – will generate interest, as well as concerns. Because the science behind biotechnology is complex, misconceptions arise over its impacts and implications.

In this publication we will answer questions many people have about biotechnology. These questions are organized along the lines of a news story: ***what, when, who, where, why, and how***. We also provide a list of additional information sources available on the Internet. Our primary focus will be on the uses of biotechnology in agriculture and food production since these appear to be more controversial than other applications (at least up until this time).

What is Biotechnology?

In its broadest sense, biotechnology refers to the use of living systems to develop products. New scientific discoveries are allowing us to better understand fundamental life processes at the cellular and molecular level. Now we can improve selected attributes of microbes, plants, or animals for human use by making precise genetic changes that were not possible with traditional methods.

All living organisms contain genes that carry the hereditary traits between generations. To understand biotechnology, it helps to compare genes with video tape. Both DNA and video tape are long, linear strings of information. This information is encoded in a particular way -- the genes encoded with DNA and the tape encoded with magnetic particles. Both the tape and the genes can be copied (cloned), or edited (recombined). Tapes tend to be relatively stable, while DNA is quite dynamic. In nature, genes are continuously modified, and DNA is commonly transferred within and between species.

It helps to understand that modern biotechnology allows a single gene (from a strand of thousands of genes) to be changed, while traditional breeding involved random mixtures of many genes. Also, some end products of biotechnology (such as corn syrup or soybean oil) do not contain any genes; they are merely products of gene action. The fact is, when we eat, all food (whether obtained from modern biotechnology or traditional methods) is broken down into simple compounds (such as amino acids or fats) that are readily digested by our bodies.

The following are some of the main applications of modern biotechnology:

Microbes: Biotechnology allows food scientists to improve the functionality of key food ingredients, such as enzymes. For over a decade, we have consumed an improved cheese enzyme developed through biotechnology. Other uses include improved types of yeast for bread, better bacteria for yogurt, and new therapies to fight food-borne illness. Genetically modified microbes are routinely used in industry (including detergents and pollution clean-up).

Plants: Biotechnology has already been used to enhance the ability of plants to fight disease and pests. Many new crops are under development that will have enhanced nutritional content (such as rice enhanced with Vitamin A that will prevent childhood blindness and/or with iron to reduce the occurrence of anemia). It will also be possible to remove undesirable substances (such as allergens or saturated fats) from food. Such plant transformation is a refinement of traditional breeding – with modern biotechnology scientists can add or remove small pieces of genetic information in a very precise manner, with a precise end result in mind.

Animals: Biotechnology makes it possible to enhance the ability of livestock and pets to overcome disease and maintain health. This has already occurred through the use of improved animal medicines and other methods of disease treatment (many of which reduce the need for antibiotics, hormones, or other production tools.) It is now possible to improve animal feed to ensure better nutrition and reduce the amount of animal waste. Biotechnology has also been used for many years to improve animal breeding, reproduction, and growth.

Humans: Through advances in biology, scientists can better determine what genetic factors contribute to either wellness or disease. Using this information, it will be possible to intervene earlier in a disease through new medicines, lifestyle changes, better nutrition, and other approaches. Diagnostic tests will make it possible to better anticipate the development of a disease before it either begins or becomes advanced. This will make it easier to practice prevention.

When did we start Using Biotechnology?

To some extent we have been using biotechnology for over 10,000 years. When our ancestors found a way to select and grow certain types of plants and animals, this was an early form of biotechnology. The industrial use of biotechnology actually started when people began using microbes to produce wine, bread, cheese, and other products (before the dawn of human history).

However, modern biotechnology began just over 100 years ago. In the mid-19th century, Charles Darwin described the processes of evolution and natural selection; while an Austrian monk Gregor Mendel discovered the laws of heredity. These opened the way to a better understanding of how species evolve and relate to their environment.

In the mid-1950's, Watson and Crick described the structure of DNA as a "double helix." This was followed in the early 1970's by the development of biotechnology techniques that allow for direct and precise modification of genetic information. The first medical product of modern biotechnology was human insulin introduced in 1978. The first food product was the cheese enzyme, chymosin, approved for use in 1990. Since the mid-1990's, the U.S. government has approved over 40 different plants developed through biotechnology.

Who is Involved with Biotechnology?

A wide range of companies, universities, interest groups and government agencies are involved with biotechnology. Each group has its own types of expertise, as well as its own concerns and interests. These groups often compete for public attention in their attempts to promote their position. The following describes the main actors in the biotechnology arena:

Scientists working at universities, government agencies, or for industry are responsible for developing the scientific understanding and tools used in modern biotechnology. This sector also includes independent scientific organizations (such as the National Academy of Sciences and the American Dietetic Association) that have publicly confirmed the safety and benefits of biotechnology.

Government agencies including the United States Department of Agriculture (USDA), Food and Drug Administration (FDA), Environmental Protection Agency (EPA), National Institutes of Health (NIH), and others are responsible for ensuring that the products of biotechnology are safe for the public and the environment. There are also a number of international bodies involved with regulating biotechnology. Overall, there is much greater oversight and control of biotechnology than there has been for earlier scientific areas (such as traditional breeding).

Companies take the discoveries about biotechnology and apply them to products. Small, entrepreneurial firms and larger established companies play important roles in this process. These firms will play an important role in our economy for decades to come.

Farmers and other producers use the results from biotechnology research and developments to raise crops, process food, and create other useful products. American producers are competing in a global market place. In order to survive economically, they need tools to ensure a profit.

Consumer and environmental groups provide for a more balanced debate and careful evaluation of biotechnology. There are several main groups that are typically vocal on biotechnology. The first is the "precautionary principle" groups. They are

opposed to biotechnology because it is not “natural”. They want little or no risk at any costs. Other concerned groups either favor organic farming or distrust corporations. On the other hand, some consumer and environmental groups support agricultural biotechnology because they see it as a way to reduce the use of chemicals and increase agricultural yields with existing resources.

Where is Biotechnology Used?

Biotechnology will have an enormous impact on every sector of society from the farm to the home, as well as in a number of industries (such as manufacturing and health care). The United States is currently the world’s leader in biotechnology. Many of the most important and far-reaching discoveries in the new biosciences are coming from universities and companies in the United States. The major biotechnology research and development leading to new products are also taking place in the United States.

In addition, US farmers have adopted new seed varieties developed through biotechnology faster than any previous agricultural innovation. Estimates of the percentage of US crop acreage planted to biotech crops in the year 2000 are as follows: Soybeans = 53%; Cotton = 65%; and; Corn = 26%. Farmers in other countries (including Canada, Argentina, and China) are embracing the products of biotechnology.

Many other countries are active in biotechnology research and development. Despite some of the negative reaction against US grain, the European Union and Japan are, in fact, trying to catch up with the fast emerging technologies. European scientists were early leaders in this scientific area, but their culture makes it much more difficult to produce the innovative new products.

Biotechnology will have a major impact in the developing countries. Countries in Africa, South America and Asia need new ways to provide food and other necessities for their rapidly growing populations. China and India have both made a major commitment to the future development of biotechnology for use in their countries, as well as for farm exports.

Why Should I Care about Biotechnology?

Biotechnology will have a significant impact on all our lives and that of future generations. Like any tool, biotechnology is being used to solve some of our problems and provide benefits to various sectors. However, as with any tool, biotechnology could have negative effects, as well as positive effects. Because so much attention has been paid to biotechnology, it is possible to anticipate and address a variety of important issues.

Allergic reactions: The FDA considers potential allergens to be a very important issue. Developers are required to systematically evaluate this possibility. Special care is taken with genes derived from foods that commonly cause food allergies. For example, about 8% of people are allergic to foods that contain milk, wheat, some seafood, or nuts. The FDA regulations state that proteins taken from commonly allergenic foods are presumed to be allergens unless demonstrated otherwise. So far,

no products on the market contain such allergens. If they do, FDA requires that they be clearly labeled biotech.

Impacts on the environment: For the most part, crops developed with biotechnology will have many positive impacts on the environment. Benefits include reduced pesticide use, improved water and soil conservation and greater safety for workers and the ecosystem. Overall, biotechnology is a key element in sustainable agriculture. Potential environmental risks from biotech crops are similar to those we face with plants developed by traditional methods. For example, potential ecological risks may arise from the widespread use of crops with genes from the common soil bacteria *Bacillus thuringiensis* (Bt). Scientists have recognized that insect populations will develop resistance to Bt just as they have to chemical pesticides. There may be risks to non-target species, such as butterflies, from plants with Bt genes (but these risks are less than those associated with chemical pesticides.) Concerns have been raised that a herbicide tolerant plant could pass that gene responsible for the tolerance on to a weed species, thus conferring herbicide tolerance. Monitoring for such effects and development of effective risk management approaches is an essential component of biotechnology regulation. Intense oversight from government and interest group helps ensure that environmental risks are examined before the plants are introduced to the environment.

Future benefits of food biotechnology: Future products developed through biotechnology will provide important consumer benefits, such as enhanced flavor and freshness, enhanced nutritional value and reduced saturated fat content. For developing countries, biotechnology can increase crop yields, thereby helping to address food shortages and hunger. In time, biotechnology may produce biodegradable packaging, alternatives to chemical pharmaceuticals, and more healthful food products (e.g. vegetables with increased quantities of antioxidants to reduce the risk of cancer.); as well as foods, when consumed, will deliver vaccines that can currently only be given by injection.

Impacts on world hunger: In the next 50 years the global population is expected to double, reaching more than 8.9 billion people by 2050. Population growth and improved diets will require at least a doubling of the food supply. The amount of land currently committed to food production – approximately 36% of the earth's cumulative land area – currently cannot yield the amount of food needed by this increased population. Although forests could be cleared to obtain needed acreage, a better approach is to find ways of getting greater crop yield from existing farmland. Biotechnology can increase food quantity and quality by addressing the factors that traditionally deplete crops: pests, weeds, drought, temperature, and wind. Plants from biotechnology can deal with these hardships and dramatically increase the percentage of crops that survive and are harvested each year. Biotechnology can help alleviate hunger worldwide, but it is not the only thing needed. Social and economic reforms will also be important.

Ethical and Social Questions: Any technology has the potential for raising a number of social, economic, and philosophical questions. Due to its power, biotechnology has raised a number of such concerns. In one sense people are uncomfortable with the ethical issues of modifying living organisms at such a fundamental level. These concerns are much more evident with animals and humans than with plant or microbes. It will be important for society to establish clear boundaries that scientists will not cross (such as human cloning). From a socio-economic standpoint, biotechnology can affect

the relationships between and relative power of different groups in society. For example, some farm groups are concerned that biotechnology will lead to a greater concentration in agricultural production and more corporate control over farming. This trend, however, has been underway for some time – due to changes in government policies and global economics, as well as advance in other types of technology.

How can we make Wise Decisions about Biotechnology?

As with any new technology we will need to work together to make sure that the benefits are maximized - while keeping the costs to a minimum. It is important to keep in mind that nothing is completely risk free. There are mechanisms in place that can ensure the products of modern biotechnology are as safe, or safer, than those produced with traditional methods. It is vital that the public continues to have a say in these important decisions.

We also must openly discuss the social and ethical issues associated with biotechnology. For example, we need to consider whether it is ethical to deny the benefits of these technologies to developing nations because of consumers' concerns in developed countries (especially in Europe). Also, we need to make sure safeguards are in place to protect the confidentiality of the data collected about our own genetic profiles, so that insurance companies and employers are not able to discriminate against people because of potential health implications related to their genetic characteristics.

Another important issue is consumer choice. Some consumer groups are asking that all foods developed with ingredients from biotechnology be labeled. The FDA already has a policy in place that will meet the needs of consumers for information and choice, while ensuring that the products are available for people in this country and around the world. They have determined after significant public comment, that foods developed through biotechnology will only be labeled if there has been a significant change in the nutritional values or safety of the final food product. To require additional labeling based on the type of production, (i.e. that it has been made using the techniques of modern biotechnology) would add significantly to the costs of food and limit availability of the benefits. Those consumers who want to avoid the products of modern biotechnology do have a clear choice. They can buy organic food that has been certified to be free of biotechnology. However, this may turn out to be a very difficult and costly promise to keep.

If you still have questions and concerns about biotechnology, we encourage you to learn more. There are a number of sources of information that should be helpful. **Most of the websites have links to many other sources of information.**

Government agencies have a lot of information about biotechnology

The Food and Drug Administration's policy for foods developed by biotechnology
<http://vm.cfsan.fda.gov/~lrd/bioeme.html>

U.S. Department of Agriculture regulatory oversight in biotechnology
<http://www.aphis.usda.gov/biotech/OECD/usregs.htm>

The North Carolina Biotechnology Center: has a good deal of information about biotechnology in N.C. as well as an excellent educational fact sheet at: <http://www.ncbiotech.org/aboutbt/foodbt.cfm>

The American Dietetics Association has a position paper on biotechnology that can be found at: <http://www.eatright.org/abiotechnology.html>

The Council for Biotechnology Information is a joint effort among the leading biotechnology companies. They can be contacted at: <http://www.whybiotech.com/>

The International Food Information Council has some very useful background information on food biotechnology and a range of other food topics. Visit their web site at <http://www.ificinfo.health.org/index14.htm>

The Alliance for Better Foods is a coalition of over 40 leading agricultural and food organizations in the United States. Their website can be found at: <http://www.betterfoods.org/>

Colorado State University has a video clip on how to make a transgenic plant. Their website is: <http://www.colostate.edu/programs/lifesciences/TransgenicCrops>

For a complete picture you may also want to review some of the material from the groups that are opposed to the use of biotechnology. The following Internet sites will provide that more critical perspective:

Greenpeace is one of the leading groups opposed to biotechnology. Their website is: <http://www.greenpeace.org/~geneng/>

The Organic Consumers Association promotes organic agriculture as a means of avoiding the products of biotechnology <http://www.purefood.org/>

To conclude we felt it would be helpful to present some of the latest views from some of the leading experts on this important topic:

"The committee is not aware of any evidence suggesting that foods on the market today are unsafe to eat as a result of genetic modification. Furthermore, we found no strict distinction between the health and environmental risks posed by plants modified through modern genetic engineering techniques and those modified by conventional breeding practices. "

National Academy of Sciences -- April 2000

"We cannot turn back the clock on agriculture and only use methods that were developed to feed a much smaller population. It took some 10,000 years to expand food production to the current level of about 5 billion tons per year. By 2025, we will have to nearly double current production again. This cannot be done unless farmers across the world have access to current high-yielding crop production methods as well as new biotechnological breakthroughs that can increase the yields, dependability, and nutritional quality of our basic food crops. We need to bring common sense into the debate on agricultural science and technology, and the sooner the better!"

Nobel Laureate Norman Borlaug -- April 2000

"One of the great consumer questions of our time is: Will the world accept biotechnology? From a purely scientific perspective, it's an odd question. We already have. Biotechnology's been around almost since the beginning of time. It's cavemen saving seeds of a high-yielding plant. It's Gregor Mendel, the father of genetics, cross-pollinating his garden peas... Our best scientists have searched for risks. Without exception, the biotech products on our shelves have proven safe."

USDA Secretary Dan Glickman -- March 1999

"Edible vaccines, delivered in locally grown crops, could do more to eliminate disease than the Red Cross, missionaries and U.N. taskforces combined, at a fraction of the cost. But none of these benefits will be realized if Western generated fears about biotechnology halt research funding and close borders to exported products."

Senator Christopher Bond -- January 2000

"As we have evaluated the results of the seeds or crops created using biotechnology techniques, we have seen no evidence that the bioengineered foods now on the market pose any human health concerns or that they are in any way less safe than crops produced through traditional breeding."

FDA Commissioner Jane E. Henney -- January 2000