

The ABCs of GMOs & The Two Sides of the GMO Debate

Overview

This handout provides an overview of the processes behind the creation of genetically modified organisms (GMOs). After reading it, consider and examine your own beliefs regarding the ethics of genetic manipulation.

Introduction¹

Every cell in every plant contains DNA: long, twisting molecules that are divided into sections called genes. Genes contain the instructions for building specific proteins. Those proteins are responsible for particular traits such as leaf shape or fruit ripening time. In recent years, scientists have begun to modify the DNA of certain crops, and as a result, the American public has been introduced to genetically engineered food. In GE crops, the genes of totally unrelated species (such as fish) are forced, using viruses or "gene guns," into the DNA of a plant (such as a tomato).

At present, most of the corn and soy grown in the US has been genetically modified. Chances are, you have already consumed GMOs (genetically modified organisms) in your breakfast cereal or in your tortilla chips and taco shells. Most people are unaware that they have eaten GMOs because companies are not required to label their products as such (2011).

While GMOs are increasingly added to the U.S. food supply without public notification, many countries in Europe have banned the cultivation and sale of GMOs, citing health risks, environmental risks, and the lack of adequate testing. What, exactly, are the potential dangers of genetically altering crops? To understand the risks we are taking, one must first understand the basics of genetic engineering.

How has it been done before?

Selective breeding utilizes the natural mating procedure – sexual reproduction – that occurs between most plants in the wild. An individual plant that displays a desired trait is applied to the egg cells of another plant that displays the same desired trait. In order for them to reproduce, the two plants must be of the same species or of closely-related species. Statistically, the offspring of those two plants are more likely to possess the desired trait.

Offspring plants that display the desired trait are selected again and bred together. This process is repeated until the offspring uniformly possess the desired trait. Selective breeding does not introduce new genetic material into the gene pool of the species. Rather, it selects for genetic traits already present in that species' gene pool. By contrast, genetic engineering techniques introduce foreign genes into the DNA of very different species.

How is it done now?

The donor organism is the plant, animal, virus, or bacterium that contains the trait the scientist desires. For example, certain cold-water fish such as flounder have proteins that keep their bodily fluids from freezing. Studying flounder cells, scientists figure out which gene codes for the "antifreeze" trait and they cut that gene from the cells using enzymes.

The target organism is the plant that will have the new genetic material added to it. For example, Canadian scientists want to inject Black Mexican Sweet

Corn cells with the flounder's anti-freeze gene. The corn is the target organism. To trick the target organism's cells into accepting and incorporating genes from an unrelated species, scientists splice together a package of several different genes from different sources.

The package contains the desired gene, a promoter gene, and a marker gene, which are explained on the later.

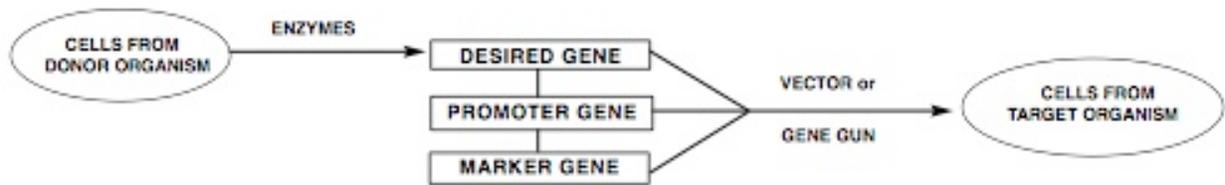
Desired gene: The desired gene codes for the proteins that dictate the trait that the scientist wants, such as the ability to survive colder temperatures. That trait is expressed only if the gene is activated, or "turned on."

Promoter gene: The promoter "turns on" the desired gene, so that it will express the trait the scientist wants it to express. One way that plant cells protect themselves from the invasion of foreign genes is by "turning off" or "silencing" the foreign genes that penetrate them. Scientists need a very tough promoter gene to get the desired gene to "turn on" once it's inside the new plant cells.

Most often, they use the Cauliflower Mosaic Virus (CaMV) because it works with almost any gene and will direct any gene to remain "on" all the time. CaMV is so strong that it is capable of controlling not only the desired gene, but other genes found within the plant.

¹ Adapted from "Biotech Breakdown" by Susan D. Horowitz, Terrain, Summer 2000; "Perils Amid Promises of Genetically Modified Foods"

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Marker gene: The marker allows scientists to identify which plant cells have been successfully transformed by the new gene package. The most common markers are genes that are antibiotic-resistant. The scientists apply antibiotic (usually kanamycin) to the plant cells they are working with, and only the ones that have successfully integrated the package of new genes survive the dose.

Afterwards, the marker remains part of the plant's genetic makeup. Increasingly, scientists are using ampicillin-resistant genes as markers. So far, five countries in Europe have banned planting corn containing ampicillin-resistant genes, fearing the genes could spread to bacteria and make it harder to treat infections. In 1999, British Medical Association called for immediate halt to antibiotic resistance genes as markers.

Gene packages are inserted into target organisms two different ways: through vectors or gene guns. Vectors are made of bits of viruses and other genetic parasites. Vectors are capable of penetrating cells, then making the cells express the vector's genetic material. The gene package is spliced into the vector, then the vector invades the target organism's cells and deposits new genes into the cell's gene code.

For the plants that resist vectors, scientist insert the gene package using "gene guns," which are microscopic pieces of gold or tungsten metal covered with DNA. They literally shoot the mixture directly into plant cells.

The Wild Card:

Notes on Horizontal Gene Transfers

When a cell comes in contact with genes from an unrelated species, the cell will break down or de-activate the foreign gene. For example, when the cells of your body come in contact with foreign genetic material, this protective mechanism keeps those genes from recombining with your genes. However, there are times when genetic material does make it inside the cell of an unrelated species and is able to recombine with the genes within. This is called horizontal gene transfer and it can happen 3 different ways:

- **Conjugation:** genes are passed between cells in contact.
- **Transduction:** genes get into a cell by an infectious virus.
- **Transformation:** genes are taken up into a cell from the environment.

Horizontal gene transfer happens frequently in the world of bacteria, and in fact, is responsible for the dramatic increase in virulent infections that resist antibiotics.

Genetic engineering is based on designing vectors that can overcome the barriers between unrelated species and stifle the cellular mechanisms that break down or deactivate foreign genes. These artificially made vectors are able to get genes into cells that would otherwise reject them, and enable the genes to replicate in cells that would otherwise not recognize them or break them down. Because these vectors are genetically similar to a wide range of disease-causing viruses, they can recombine with them easily to generate new viruses.

Most GMOs contain genes that haven't regularly been in our diets before, such as the marker genes that code for antibiotic resistance. There exists the distinct possibility that the antibiotic-resistant genes inserted during genetic engineering will be taken up by the many bacteria that live in our digestive tracts, which are then free to transfer those resistance genes to disease-causing bacteria. Biotech companies do not have the technology to prevent the genes they insert into target cells from ultimately recombining with all sorts of unintended targets.

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Arguments FOR Genetic Modification:

- Improved nutrition may result when vitamins and minerals are added. Syngenta's "Golden Rice" is engineered to contain beta carotene, which the body converts to Vitamin A. Biotech companies say this will aid malnutrition-related blindness in developing countries.
- Crops may be engineered to address specific health problems. Soybeans may be engineered to have higher levels of monounsaturated fatty acids and lower levels of polyunsaturated fatty acids, reducing harmful cholesterol buildup. Scientists are experimenting with introducing a vaccine into potatoes in order to treat intestinal diseases in developing countries.
- Some GMOs may lead to reduced herbicide and pesticide use. The Bt corn plant is genetically engineered to produce its own insecticide, the *Bacillus thuringiensis* (Bt) delta endotoxin. It was created in order to control corn borer caterpillars. By introducing the gene that produces the endotoxin into the corn plant, growers can supposedly reduce the amount of chemicals used to control the pest.
- Cheaper and more abundant food supplies may result. Roundup Ready soybeans will survive applications of Monsanto's herbicide, Roundup, which kills competing weeds. Biotech companies claim that higher yields will result because the soybean plants will not have to compete against weeds for space, light, and nutrients. Higher yields potentially may lead to lower prices.
- Crops can become more tolerant of harsher weather conditions, such as drought or cold. Canadian researchers are experimenting with a Black Mexican Sweet Corn that contains a flounder's anti-freeze gene. Certain cold-water fish such as flounder have proteins that prevent their bodily fluids from freezing. The aim is to transplant the genes that code for those proteins into crops so that they'll be more resistant to freezing. People who live in areas where harsh conditions lead to crop failure may be able to grow crops engineered to endure such conditions.
- Plants may be engineered to produce better-looking fruits, vegetable, flowers, etc. Biotech scientists may engineer apples of perfect size and shape, or flowers that may last weeks in a vase. More attractive produce and flowers may lead to more sales.

Arguments AGAINST Genetic Modification:

- New bacteria and viruses may be created. After the promoter gene CaMV is inserted, it can separate from the donor chromosomes and recombine with other genes, such as dormant viruses already in the plant or in your gut.
- GMOs may prove toxic to unintended species. Pollen from Bt corn has shown, in some studies, adverse impacts to monarch butterfly larvae.
- People may suffer allergic reactions to GMOs and not be able to identify or avoid the allergen. Biotech companies only test for known allergens, not for any new allergens or toxins, even though they are introducing substances that have never before been in the food supply. As it is, about 150 Americans die each year from severe allergic reactions to food, for which there is no treatment other than avoidance. Lack of labeling compounds this problem.
- Resistance to antibiotics, a problem on the rise, may increase. According to the WHO, at least 30 new diseases have emerged over the past 20 years, while old, infectious diseases like tuberculosis and cholera are making a comeback. Practically all of these are proving resistant to antibiotics. The practice of genetic modification relies on releasing antibiotic-resistant genes into the food supply.
- Some GMOs lead to increased pesticide and herbicide use, which destroys indigenous crops and native species in the area. GMOs such as Roundup Ready soybeans are engineered to be used together with specific herbicides. Through run-off and airborne drift, herbicides can affect neighboring farms, pollute groundwater, and poison wildlife.
- More sustainable farming practices will be endangered. GMOs are primarily grown as monocrops. A major cause of malnutrition worldwide is the substitution of a traditionally varied diet for one based on monocrops. Growing a variety of foods ensures long-term food security, whereas monocropping (growing a single crop) is a practice that makes fields notoriously prone to disease and pest outbreaks, even when GMOs are grown.
- While biotech companies prosper, the livelihood of American farmers will be compromised. Even if a farmer chooses not to grow GMOs, pollen from genetically modified crops can easily drift over and contaminate the farmer's field. If the farmer grows organically, he/she may lose organic certification. If the farmer relies on selling to European markets, contamination will render the crop unsellable, for most European countries ban GMOs.