

GENETIC ENGINEERING Science Page

UNITED STATES BOTANIC GARDEN
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DID YOU KNOW?

More than 60 percent of the foods that Americans purchase from the supermarket today contain genetically modified (GM) crops.



some GM groceries

WHAT IS GENETIC ENGINEERING?

Genetic engineering involves moving genes from one organism into another. Scientists pinpoint a desirable trait in one organism, isolate the gene responsible for the trait, remove it, and then transfer it to another organism.

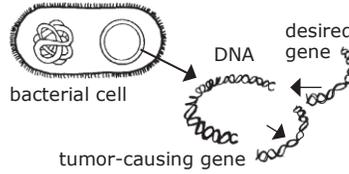
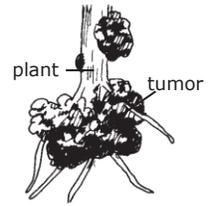


Scientists added genes to soybeans to make them resistant to weed killer. When we spray our soybean fields with the weed killer, the weeds die, but the GM soybeans survive.

HOW DOES GENETIC ENGINEERING WORK?

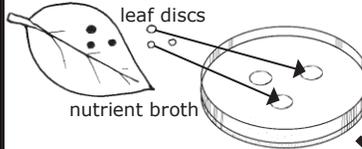
Scientists use various methods to add genes to an organism's DNA. One method to transfer genes uses a soil bacterium.

The soil bacterium *Agrobacterium tumefaciens* has a ring of DNA that naturally inserts itself into the DNA of plant cells and causes tumors.



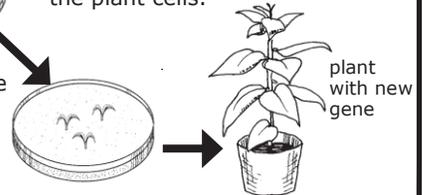
The tumor-causing gene is cut out of the bacterium's DNA. The desired gene from the donor organism is pasted into the DNA in its place.

The DNA is put back into a bacterial cell. The cell is put in a nutrient broth, where it multiplies. Each new bacterial cell has the new gene.



A piece of leaf is placed in the nutrient broth. The DNA with the new gene enters some of the plant cells.

Leaf cells with the new gene are put in a special growth medium where they grow into complete plants. Every cell in the new plant contains the new gene.

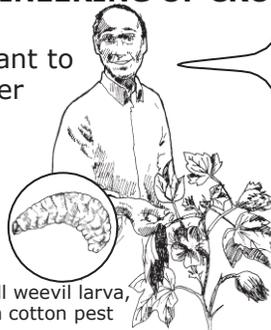


When the plants mature, they make seeds that carry the new gene.

WHY IS GENETIC ENGINEERING OF CROPS BEING DONE?

- * To make crops resistant to insects and weed killer

A gene from a soil bacterium called Bt produces a protein that is toxic to pests of corn and cotton. Scientists added this gene to the DNA of corn and cotton, so the plants contain the insecticide.

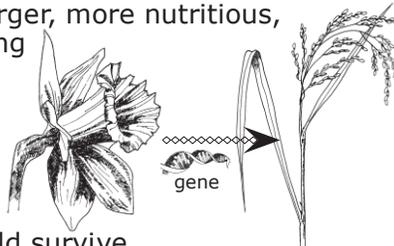


boll weevil larva, a cotton pest

Farmers don't have to spray a lot of insecticides on Bt crops because when insect pests try to eat Bt crops, they get sick and die.

- * To make foods that are larger, more nutritious, tastier, or that resist rotting

A daffodil has a gene for making vitamin A. Scientists can add this daffodil gene to a rice plant. In this way, rice plants can produce more vitamin A. People need vitamin A for healthy eyes, skin, bones and teeth.



- * To develop crops that could survive where they normally would not

Scientists can take a gene from the *E. coli* bacterium, and add it to rice. This GM rice is able to withstand drought, salt water and cold temperatures.



WHAT SOME PEOPLE ARE SAYING ABOUT GM CROPS

GM crops are owned by the companies that develop them. So farmers can't save seeds of GM crops to plant the following year. I don't like that idea.



Nearly all US farmers buy their seed each year anyway, but this might be a concern for farmers in some poorer countries.



I'm more concerned that GM crops might harm the environment and reduce biodiversity.



Pests damage crops. So we need ways to manage them but not harm the environment. Perhaps GM crops can do both, but we do need to examine them carefully, and compare them to alternative technologies.



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PUZZLE

Put these steps for making Bt corn in the right order.

- Place a piece of cotton leaf in the nutrient broth containing GM bacteria.
- Cut the tumor-causing gene out of the DNA of *Agrobacterium tumefaciens*. Replace it with the Bt gene for making natural insecticide.
- Place the leaf cells containing the new gene in a special growth medium where they can grow into complete plants.
- Isolate and cut out the gene for making a protein toxic to cotton boll weevil larva from the soil bacterium called Bt.
- Put the GM DNA ring back into a bacterial cell, and put the cell in nutrient broth and let it grow and multiply.



TRY THIS

GM Crops Debate

The debate over GM crops is one of the fiercest of recent times. Genetic engineering is also one of the most misunderstood technologies. It is important to keep an open mind, to stay informed, and to keep debating the pros and cons of GM crops.

What you need

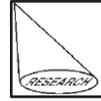
- * Paper and pencil

What to do

- Review the information on the pros and cons of genetic engineering on this Science Page. You may wish to do some research on the Internet to find out more about the GM crops debate.
- Make a chart with two columns labeled "Pro" and "Con." In the Pro column, list how GE technology can benefit the environment, human health, and the economy. For each argument, list a counter argument in the "Con" column.
- Organize two debate teams, one to argue in favor of GM crops, and the other to argue against them. There should be two rounds of the debate. In each round, the "Pro" team presents their arguments, and then the "Con" team cross-examines them, that is, asks questions about the arguments that were presented. Then the "Con" team presents their arguments, and the "Pro" team cross-examines them. After two rounds, the "Con" team presents their rebuttal, and then the "Pro" team presents their rebuttal. (In a rebuttal, you try to

explain, counteract or disprove facts given by the other team.)

- Those watching the debate can vote on which team they think won the debate, that is, which team presented the most convincing arguments.



SPOTLIGHT ON RESEARCH

Preventing insect pests from becoming resistant to GM crops

Farmers like to grow Bt crops because they do not need to spray as many pesticides. This saves money, and is good news for their health and the health of the environment too. However, farmers worry that insect pests will become resistant to Bt and be able to come back and attack their crops. Insects have developed resistance to many different insecticides so this threat is real. Scientists at Cornell University are developing ways to delay insects from developing resistance to Bt. They did a study on Bt broccoli and diamondback moths, one of the world's major insect pests.

The Bt bacterium makes several toxins (proteins that are toxic to insects), each one coded by a different gene. The researchers engineered broccoli with either one gene or two genes for Bt toxins. They bred moths, a small percentage of which were resistant to a single Bt toxin. The moths were released into caged growing areas with broccoli plants with either one Bt gene, two Bt genes, or a mix of plants with either one or two Bt genes. The moths were allowed to grow and multiply for two years (24 generations). All of the moths developed a lot of resistance to Bt toxins except those caged with plants with two Bt genes.

These results strongly suggest that Bt crops should contain two Bt genes, rather than just one. Many companies have taken heed and are already developing GM crops with two Bt genes.

Source: Zhao, Jian-Zhon, Cao, J, Li, Y, Collins, H.I, Roush, R.T., Earle, E.D, and Shelton, A.M. 2003. Transgenic plants expressing two *Bacillus thuringiensis* toxins delay insect resistance evolution. *Nature Biotechnology*. 21:1493-1497.



QUOTE

"I happen to believe that we will ultimately produce a better agriculture using [genetic engineering] technology, but I don't think all the questions have been answered yet."

Dan Glickman, USDA Secretary under President Clinton

Answer to puzzle
D, B, E, A, C