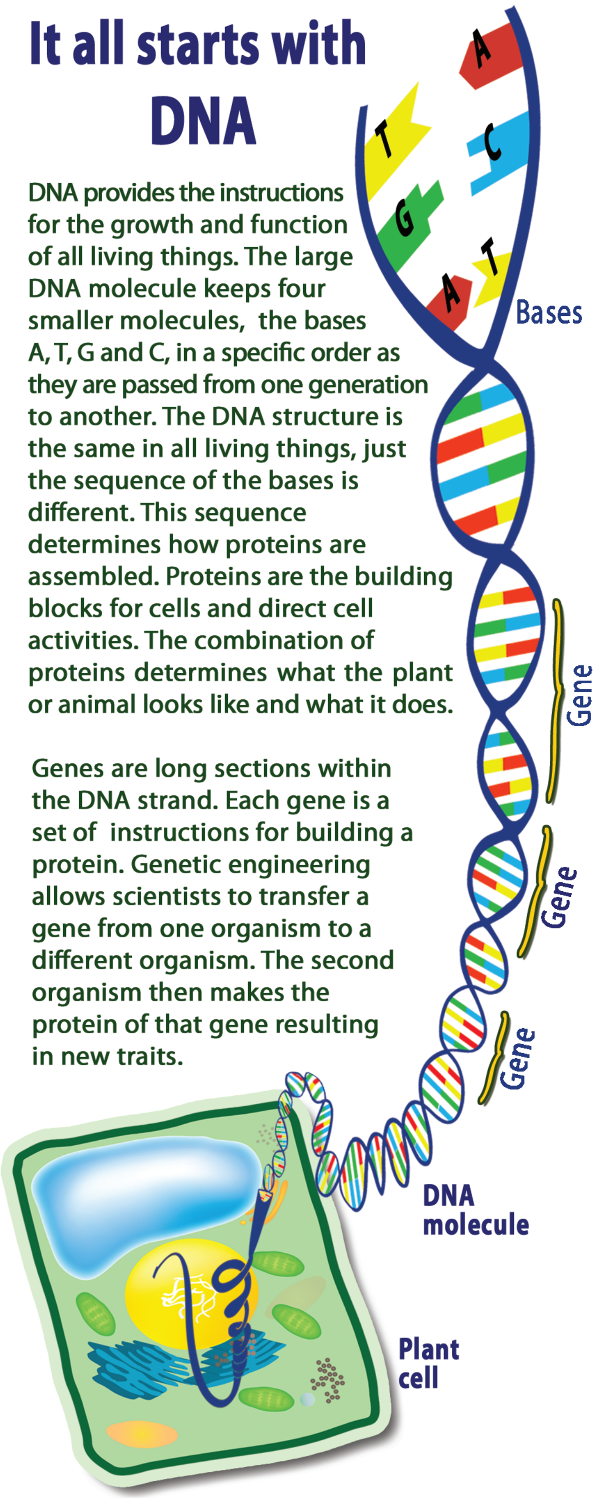
It all starts with DNA

DNA provides the instructions for the growth and function of all living things. The large DNA molecule keeps four smaller molecules, the bases A, T, G and C, in a specific order as they are passed from one generation to another. The DNA structure is the same in all living things, just the sequence of the bases is different. This sequence determines how proteins are assembled. Proteins are the building blocks for cells and direct cell activities. The combination of proteins determines what the plant or animal looks like and what it does.

Genes are long sections within the DNA strand. Each gene is a set of instructions for building a protein. Genetic engineering allows scientists to transfer a gene from one organism to a different organism. The second organism then makes the protein of that gene resulting in new traits.



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Agricultural Genetic Engineering

Farmers are under pressure to increase production, control costs, and reduce the environmental impacts of agriculture. Challenges they face include extreme weather such as drought and flooding, insects that literally eat the profits, diseases such as viruses and fungi, and weeds that can take over fields. The College of Tropical Agriculture and Human Resources at the University of Hawaiʻi at Mānoa provides research and educational resources to strengthen agriculture as part of a sustainable, diversified economy. The college supports the use of a range of tools to meed the needs of the farming community. These include classical breeding, organic methods, and integrated pest management as well as new technologies such as tissue culture and genetic engineering. This brochure explains the process and uses of genetic engineering.

Genetic Engineering in Agriculture

Genetic engineering is a laboratory technique where changes are made directly to the DNA of an organism. The technology is useful when more traditional methods cannot achieve the desired results. The following examples show some of the applications of genetic engineering in agriculture.

Papaya ringspot virus can wipe out a papaya field in a matter of months. Traditional control methods were ineffective and entire farms had to be relocated when the virus moved into an area. Scientists discovered that inserting a piece of virus DNA into the plant acts like a vaccine. The inserted gene, which makes a protein for the coating around the virus, does not harm the plant. The papaya plant recognizes that it does not need this protein and learns to turn the gene off. If the plant is later exposed to the virus, it will continue to turn that gene off in the virus. The virus cannot reproduce without this protein.

Crops such as soybeans and cotton have been genetically engineered for easier weed control. The glyphosate herbicide works by binding to an enzyme (a type of protein) that plants need to survive. A gene found in bacteria makes a form of this enzyme that is not sensitive to the herbicide. Plants that have this gene added are herbicide tolerant, allowing farmers to spray for weeds without harming the crop.

The majority of the corn used in processed foods has been genetically engineered for insect resistance by inserting a gene from a common soil bacterium. The Bt gene makes a protein that freezes up the digestive tract of specific insect groups.

Classical breeding using sexual reproduction can be used to combine traits from closely related plants. However, getting a particular combination of genes is a random process. Genetic engineering can be used to select and transfer a specific gene. Scientists have used this method to move a gene from flood-resistant rice into a popular variety of rice.

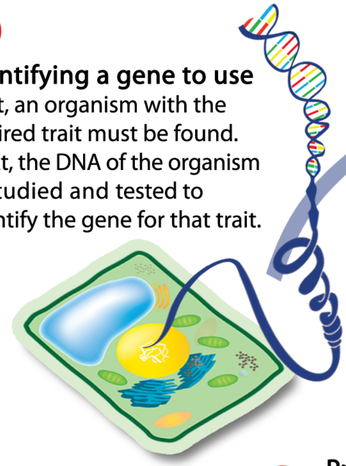
Steps to Developing a Genetically Engineered Food

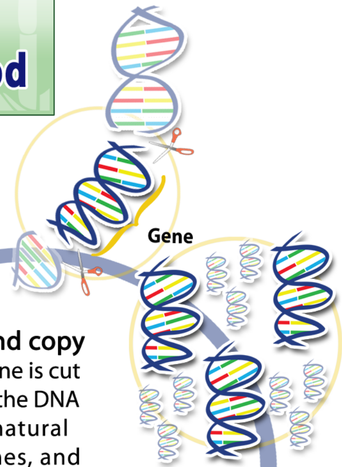
It takes about 10 years to bring a genetically engineered food to market. In addition to years of laboratory work and plant testing, scientists must complete a lengthy deregulation process .

1

Identifying a gene to use

First, an organism with the desired trait must be found. Next, the DNA of the organism is studied and tested to identify the gene for that trait.





2

Cut and copy

The gene is cut out of the DNA using natural enzymes, and many copies are made.

3

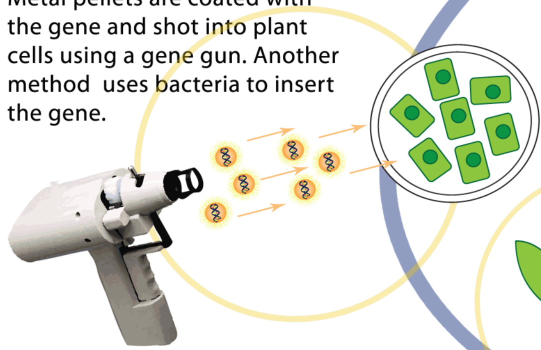
Prepare for transfer

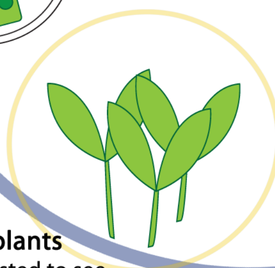
Additional genes are added to turn the gene on and off and to show that the gene was inserted successfully.

4

Insert DNA into plant cell

Metal pellets are coated with the gene and shot into plant cells using a gene gun. Another method uses bacteria to insert the gene.

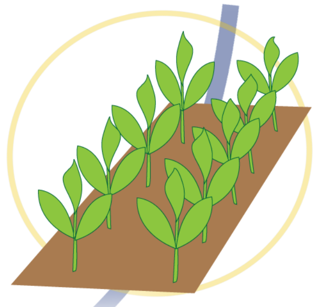




5

Grow and select plants

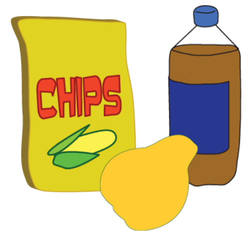
The plant cells are tested to see if they have the desired gene. Cells that have been transformed are grown, and the best plants are selected to be developed into plant lines.



6

Field testing

Researchers must obtain a permit from the Biotechnology Regulatory Services of the U. S. Department of Agriculture before field testing of the selected plant line begins. Strict guidelines are used to prevent the plant from spreading into the environment.



7

Approval for sale

Information on nutrition, food safety and environmental impacts is submitted to federal regulatory agencies for review. No further monitoring is required once a plant has been approved for commercial use.