Fact Sheet

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Genetic engineering

What is genetic engineering?

Genetic engineering is the process of changing the characteristics of plants or animals by adding, subtracting or changing the function of genes.

Genetic engineering is also known by a number of other names:

- genetic modification
- transformation
- recombinant DNA technology
- gene splicing
- gene manipulation.

What use is it?

Genetic engineering is a powerful technology. By adding a new gene, or changing an existing gene in a plant, we can make plants produce more grain, resist disease or produce new products.

Genetic engineering has already been used to make plants:

- resistant to pest insect attack
- more nutritious
- produce novel coloured flowers (eg blue carnations)
- safer for animals and humans.

As genetic research continues, there will soon be many more applications of genetic technology available.

How does it work?

All living things are made up of building blocks called cells, which contain DNA – the 'instructions' for building a living thing. Regardless of whether it is taken from a daffodil or an antelope, the instructions are written in the same code – DNA. It is the order of the code that dictates the species, gender and individual characteristics of an organism.

Because all living things use the same kind of code, it is possible to transfer a specific piece of DNA between organisms to change a particular characteristic of the recipient. However, an adult plant is made up of millions of cells, so it would be impossible to change the DNA of every single cell one by one. We must start with a single cell from which we will grow the new plant.

Transferring DNA from one organism to another is a five-step process.

1. Finding the gene of interest

Firstly, researchers must know precisely where in the plant's genome the gene of interest is located. Many plants have around 30,000 genes, so this step can be difficult and quite time consuming.

2. Cutting DNA fragments

The second step involves taking the section of DNA we are interested in and cutting it out. Restriction enzymes are tools derived from living organisms that allow the very precise cutting of DNA. In bacteria, restriction enzymes act as a natural defence against viruses. Different species of bacteria have different kinds of restriction enzymes that each cut DNA at very specific points in the sequence. Scientists use restriction enzymes to cut a specific piece of DNA.

3. Multiplying DNA fragments

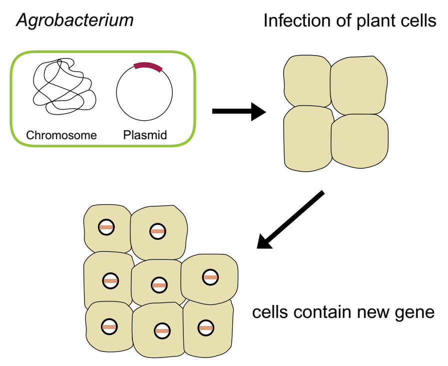
The piece of DNA then needs to be replicated so that we have millions of copies. Because bacteria are easily grown in the lab, a bacterial vehicle or 'vector' is the perfect way to do this. By 'pasting' the DNA into a section of bacteria DNA, we can produce many additional copies. Every time a new bacterium is produced, so is a new section of the DNA.

4. Introduce into host cell

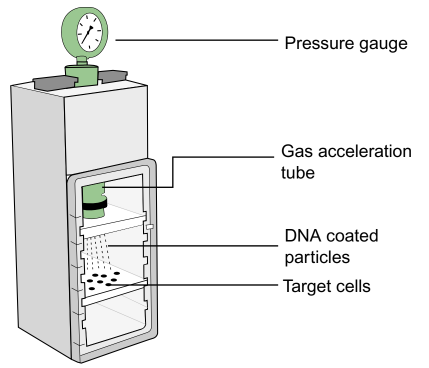
There are a number of methods for introducing our vector into a new host cell. One commonly used vector is a soil bacterium (*Agrobacterium*) that naturally infects certain plants, and inserts a piece of its DNA. Once *Agrobacterium* has multiplied our DNA fragments, we can allow it to infect the plant tissue and insert our gene of interest into the host plant's DNA.

Another method, known as 'biolistics', involves shooting the DNA into the cell using a helium-powered gun. Tiny particles of gold are coated with a different kind of vector (containing the DNA) and fired into the tissue at great speed. Some of the plant cells die, but others incorporate the new DNA into the host's DNA.

Agrobacterium-mediated transformation



Biolistic transformation



5. Screening

While the above steps may sound simple, our new plant tissue still needs to be tested to make sure the section of DNA has been properly incorporated into the new plant, and that it is working correctly. Sometimes it can be difficult to visually tell the difference between a successful transfer and a failure.

Plant researchers have a number of sophisticated methods for testing genetically engineered plants. Some tests involve growing the plants in a special gel in which only the plants with the newly introduced gene sequence can live. Other tests involve a different type of gel that changes colour when a particular gene is present in the plant tissue.

Once tested, the plants go through a lengthy process of evaluation, to make sure they perform in the field.

Case study: hayfever-free ryegrass

Genetic modification does not have to involve transferring DNA from one species to another. Often researchers are interested in increasing or decreasing the production of products already present in the plant. One such example has occurred in ryegrass.

Ryegrass is common in lawns and recreational areas as well as pasture for grazing animals. Hayfever and seasonal allergic asthma due to grass pollen affects millions of Australians.

Researchers at the Molecular Plant Breeding CRC wanted to develop a variety of ryegrass with the gene responsible for the protein in pollen that causes hayfever 'switched off'. Using the techniques described above, the relevant gene was identified and isolated from the ryegrass. A copy of the gene was made and then reversed so that the code ran backwards. The new gene construct was then reintroduced back into the ryegrass using biolistic transfer, next to the original gene. When the plant tries to make the allergy-causing protein, the DNA instructions can't be read properly and the protein is not produced.

The hayfever-free ryegrass is currently undergoing field trials in the United States.

What happens next?

In Australia, genetically modified plants must be subjected to rigorous health and environmental testing before they can legally be grown. For a detailed explanation of this process visit the Office of the Gene Technology Regulator website www.ogtr.gov.au or call 1800 181 030.

Established and supported under the Australian Government's Cooperative Research Centre Program.

For further information visit www.molecularplantbreeding.com

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