What is genetic engineering?

Genetic engineering refers to the direct manipulation of DNA to alter an organism's characteristics (phenotype) in a particular way.

What is genetic engineering?

- Genetic engineering, sometimes called genetic modification, is the process of altering the DNA in an organism's genome.
- This may mean changing one base pair (A-T or C-G), deleting a whole region of DNA, or introducing an additional copy of a gene.
- It may also mean extracting DNA from another organism's genome and combining it with the DNA of that individual.
- Genetic engineering is used by scientists to enhance or modify the characteristics of an individual organism.
- Genetic engineering can be applied to any organism, from a virus to a sheep.
- For example, genetic engineering can be used to produce plants that have a higher nutritional value or can tolerate exposure to herbicides.

How does genetic engineering work?

To help explain the process of genetic engineering we have taken the example of insulin, a protein that helps regulate the sugar levels in our blood.

- Normally insulin is produced in the pancreas, but in people with type 1 diabetes there is a problem with insulin production.
- People with diabetes therefore have to inject insulin to control their blood sugar levels.
- Genetic engineering has been used to produce a type of insulin, very similar to our own, from yeast and bacteria like *E. coli*.
- This genetically modified insulin, 'Humulin' was licensed for human use in 1982.

The genetic engineering process

the bacteria or yeast cell.

2. A small section is then cut out of the circular plasmid by restriction enzymes, ‘molecular scissors’.

3. The gene for human insulin is inserted into the gap in the plasmid. This plasmid is now genetically modified.

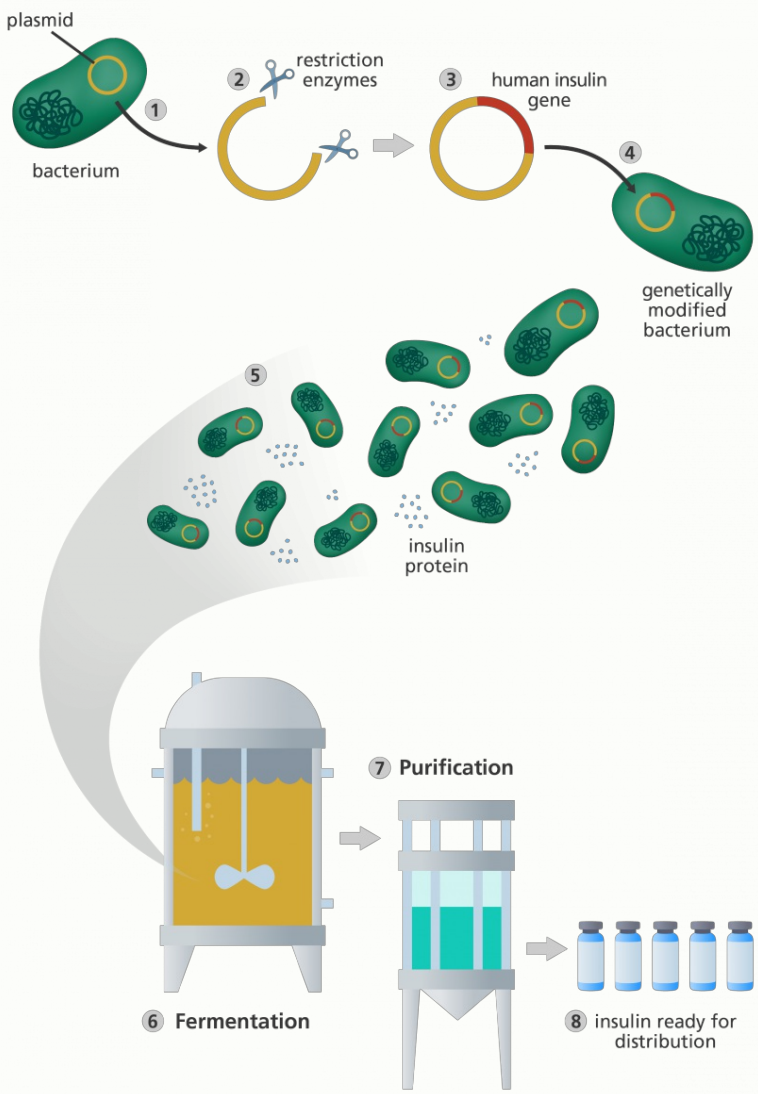
4. The genetically modified plasmid is introduced into a new bacteria or yeast cell.

5. This cell then divides rapidly and starts making insulin.

6. To create large amounts of the cells, the genetically modified bacteria or yeast are grown in large fermentation vessels that contain all the nutrients they need. The more the cells divide, the more insulin is produced.

7. When fermentation is complete, the mixture is filtered to release the insulin.

8. The insulin is then purified and packaged into bottles and insulin pens for distribution to patients with diabetes.



An illustration showing how genetic modification is used to produce insulin in bacteria.

Image credit: Genome Research Limited

What else is genetic engineering used for?

- The first genetically modified organism to be created was a bacterium, in 1973.
- In 1974, the same techniques were applied to mice.
- In 1994 the first genetically modified foods were made available.
- Genetic engineering has a number of useful applications, including scientific research, agriculture and technology.
- In plants, genetic engineering has been applied to improve the resilience, nutritional value and growth rate of crops such as potatoes, tomatoes and rice.
- In animals it has been used to develop sheep that produce a therapeutic protein in their milk that can be used to treat cystic fibrosis, or worms that glow in the dark to allow scientists to learn more about diseases such as Alzheimer's?.

Alzheimer's disease and the worm

- The nematode worm, *C. elegans*, only has around 300 cells in its entire nervous system, making it a very simple model for studying Alzheimer's disease.
- Also, due to the fact the worm is nearly transparent, when their nerve cells are labelled with green fluorescent protein (GFP), it is possible to watch the location and activity of various structures and proteins under the microscope.
- The genetic material of *C. elegans* can easily be genetically modified to make the worm produce specific proteins the researchers want to study.
- In humans, the *APP* gene codes for a protein associated with the amyloid plaques that are characteristic of people with Alzheimer's disease.
- So, to study Alzheimer's, the researchers genetically engineered the nerve cells of the worm to contain the *APP* gene, effectively giving it Alzheimer's.
- By tagging the APP protein produced in the worm with green fluorescent protein it was possible to see that all the cells that made contact with APP died as the worm got older.
- The researchers were then able to monitor the progression of Alzheimer's disease in the worm and go on to apply their findings to understanding the role of APP in humans with Alzheimer's disease.

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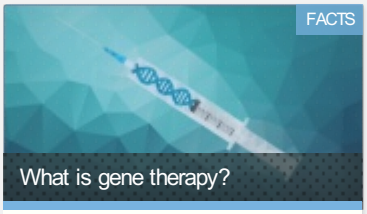
What is DNA?

DNA or deoxyribonucleic acid is a long molecule that contains our unique genetic code. Like a recipe book it holds the instructions for making all the proteins in our bodies.

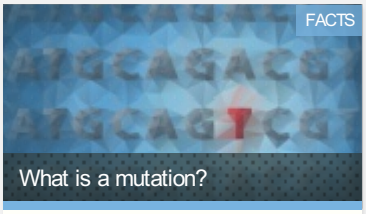
What is a GMO?

GMOs are organisms that have had their characteristics changed through the modification of their DNA.



What is gene therapy?

Gene therapy is when DNA is introduced into a patient to treat a genetic disease. The new DNA usually contains a functioning gene to correct the effects of a disease-causing mutation.

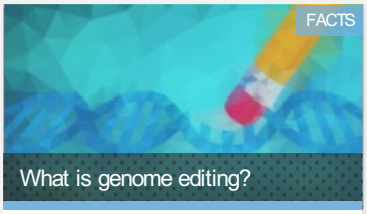


What is a mutation?

A mutation is a change that occurs in our DNA sequence, either due to mistakes when the DNA is copied or as the result of environmental factors such as UV light and cigarette smoke.

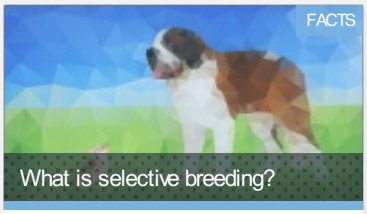
What are single gene disorders?

Single gene disorders are caused by DNA changes in one particular gene, and often have predictable inheritance patterns.



What is genome editing?

Genome editing is a way of making specific changes to the DNA of a cell or organism. An enzyme cuts the DNA at a specific sequence, and when this is repaired by the cell a change or 'edit' is made to the sequence.



What is selective breeding?

Selective breeding involves selecting parents that have characteristics of interest in the hope that their offspring inherit those desirable characteristics.