Genetic jargon

Match the genetic term to its description

chromosome	the small molecules that join to make proteins
DNA	a section of DNA that codes for a protein
gene	the molecule that genes are made of
bases	the type of molecule that genes code for
protein	a long, tightly-coiled molecule of DNA
amino acid	the chemicals in DNA that carry the genetic code

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solve

Genes and Genetic Engineering

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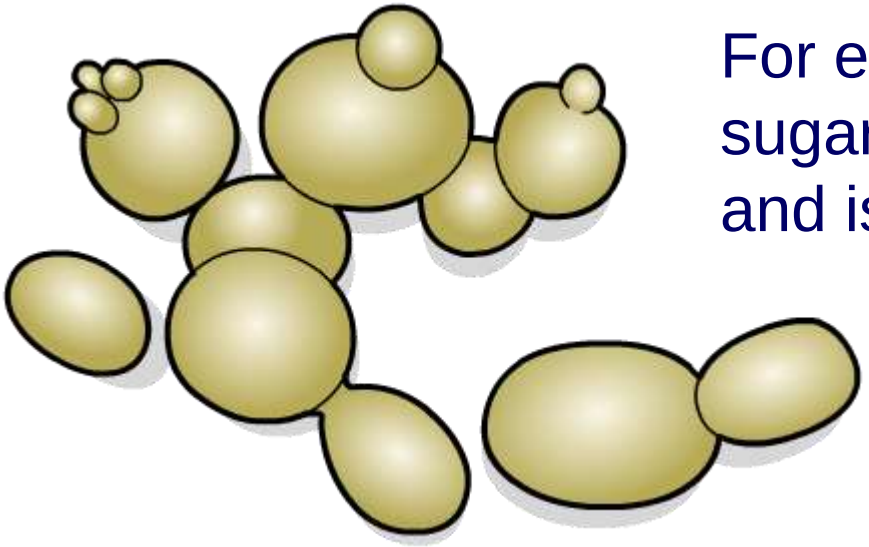
What is genetic engineering?

Living things naturally create useful products.

Genetic engineering can be used to make living things produce other, more valuable, products.



For example, yeast naturally converts sugar into carbon dioxide and alcohol, and is used in baking and brewing.

Yeast can also be genetically engineered to produce vaccines for human diseases.

Genetic engineering is about changing the DNA of a living thing to change its characteristics.

How does genetic engineering work?

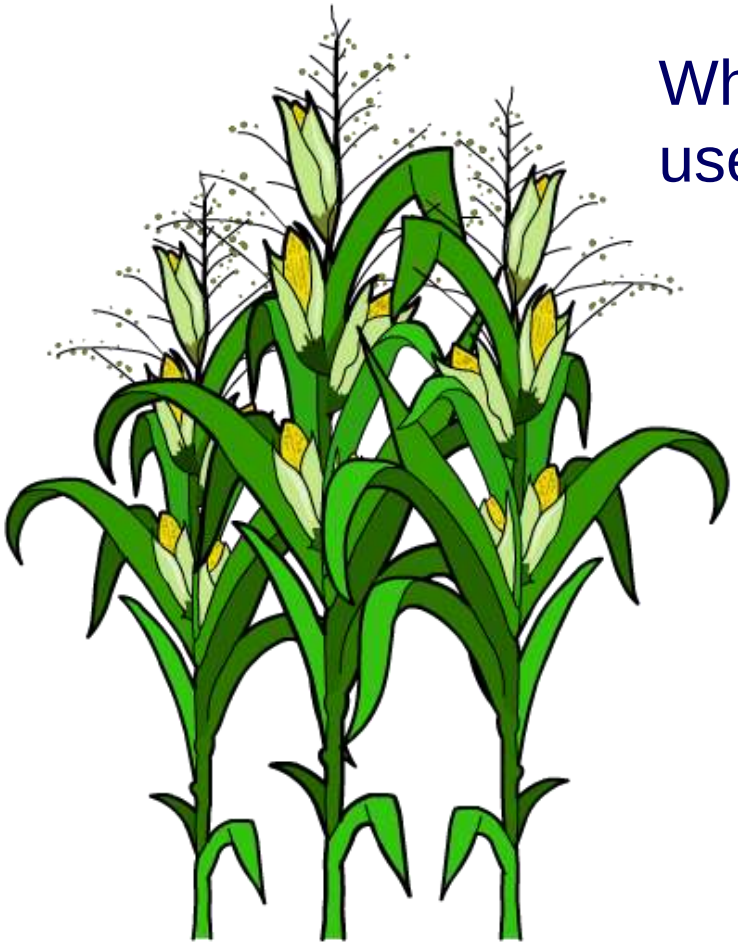
Genetic engineering involves four main stages.

Stage	Example
1. Select the product or characteristic needed	antigen for hepatitis B
2. Isolate genes from specialist cells	hepatitis B virus
3. Insert the genes into target cells	yeast
4. Replicate the new organism	yeast culture in fermenters

What is the product in this example? Hepatitis B vaccine.

GM crops

Crops can be given extra genes for new and useful characteristics. They are **genetically modified** (GM).

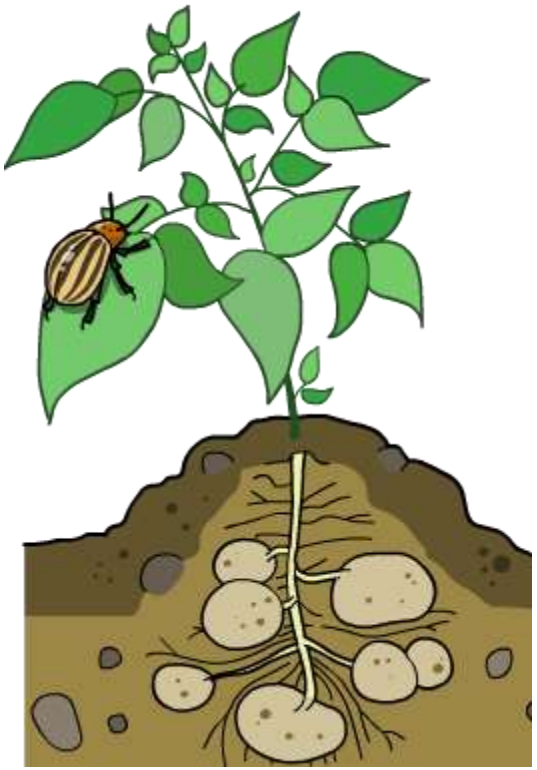


What characteristics might be useful in crops?

- pest resistance
- frost resistance
- disease resistance
- herbicide resistance
- drought resistance
- longer shelf life

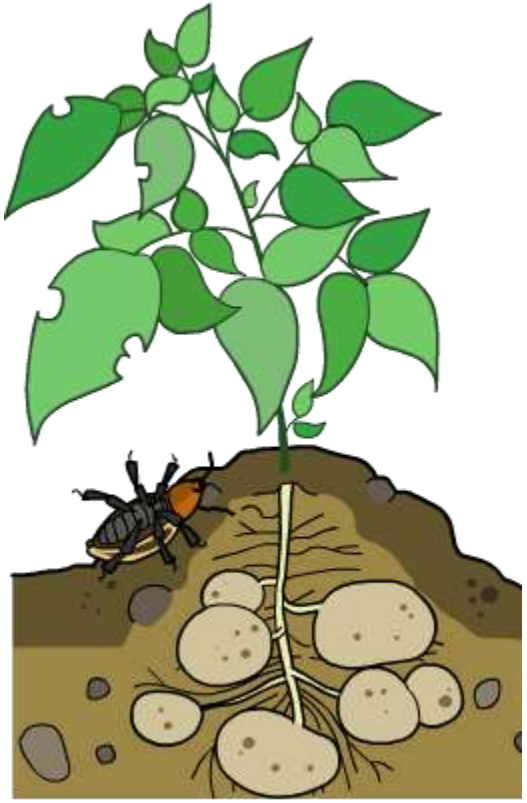
Pest-resistant crops

Potatoes can be genetically modified so they are toxic to pests, such as the Colorado beetle.



The gene for a powerful bacterial toxin is added to the potato plant.

If the beetle tries to eat the potato plant, it is killed by the toxin.

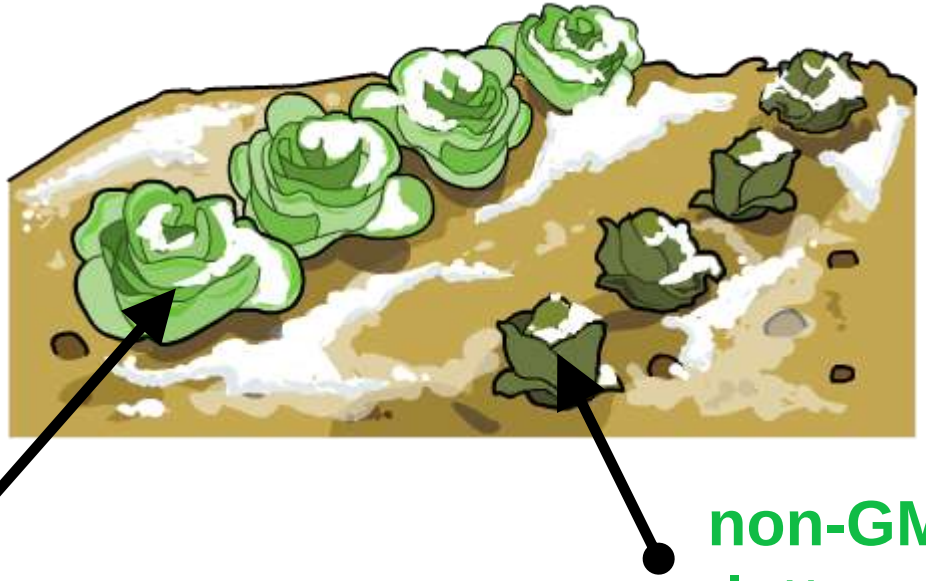


What benefits might this have for the environment?

Frost-resistant crops

Crops can be genetically modified so they are resistant to adverse environmental conditions.

For example, lettuces could be genetically modified to be resistant to frost.



Why are some people against the development and use of GM crops?

Plants with extra vitamins

Rice can be genetically modified to make beta-carotene, a substance that is converted into vitamin A in the body.

The colour of the rice is an indication of how much more beta-carotene it contains.

The GM rice is called '**Golden Rice**' and is being developed to help fight vitamin A deficiency and blindness in developing countries.

Should GM crops be allowed?

What are the advantages and disadvantages of GM crops?

advantages	disadvantages
GM crops could give bigger yields ✓	GM crops could reduce biodiversity ✓
GM crops could grow in harsher conditions ✓	The new proteins in GM crops could cause allergies ✓
GM crops could result in cheaper food ✓	Accidental transfer of new genes to other plants ✓
GM crops would need fewer chemical sprays ✓	GM seeds are expensive ✓

Well done!

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C solve

Early genetic engineering

People have been doing a simple form of genetic engineering for thousands of years. This is called **selective breeding**.

Selective breeding, or **artificial selection**, is a process where people try and improve plants and animals by selecting and breeding only those that have desirable characteristics.

For example, a farmer might choose the two largest cattle in his herd and breed them together so that the offspring will be even bigger and produce more meat.

Examples of selective breeding

Many plants and animals are selectively bred to improve their characteristics, for example:

- breeding sheep to produce more wool
- breeding wheat to produce more grain
- breeding tomatoes to become tastier.

Other examples include breeding racing horses to become faster, and breeding dogs to obtain unique characteristics (e.g. bulldog, greyhound, chihuahua).

Genes and Genetic Engineering

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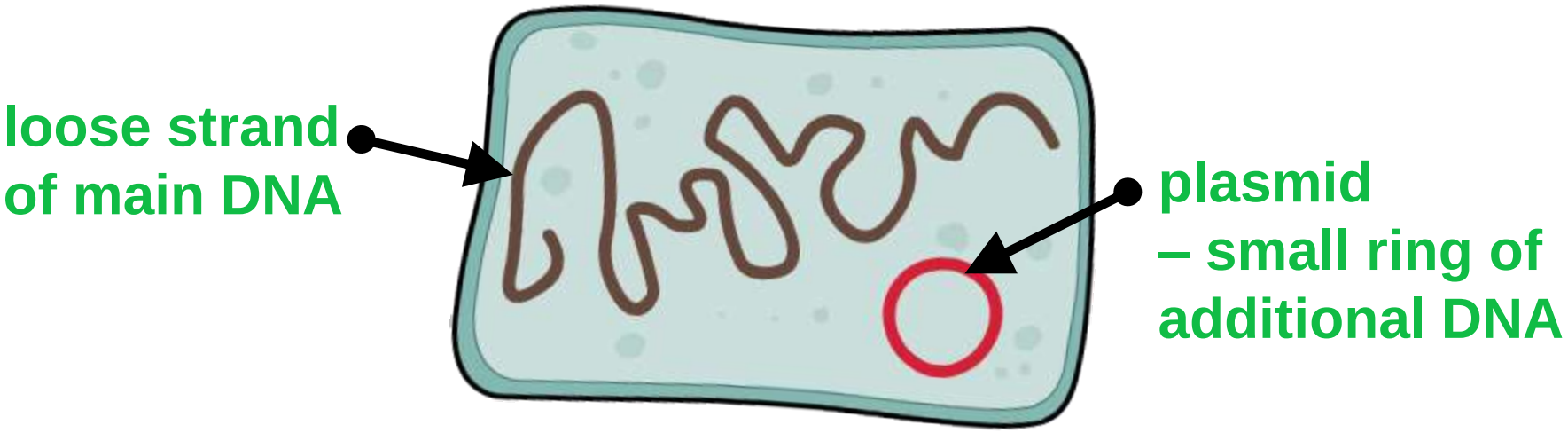
Changing the genetic code

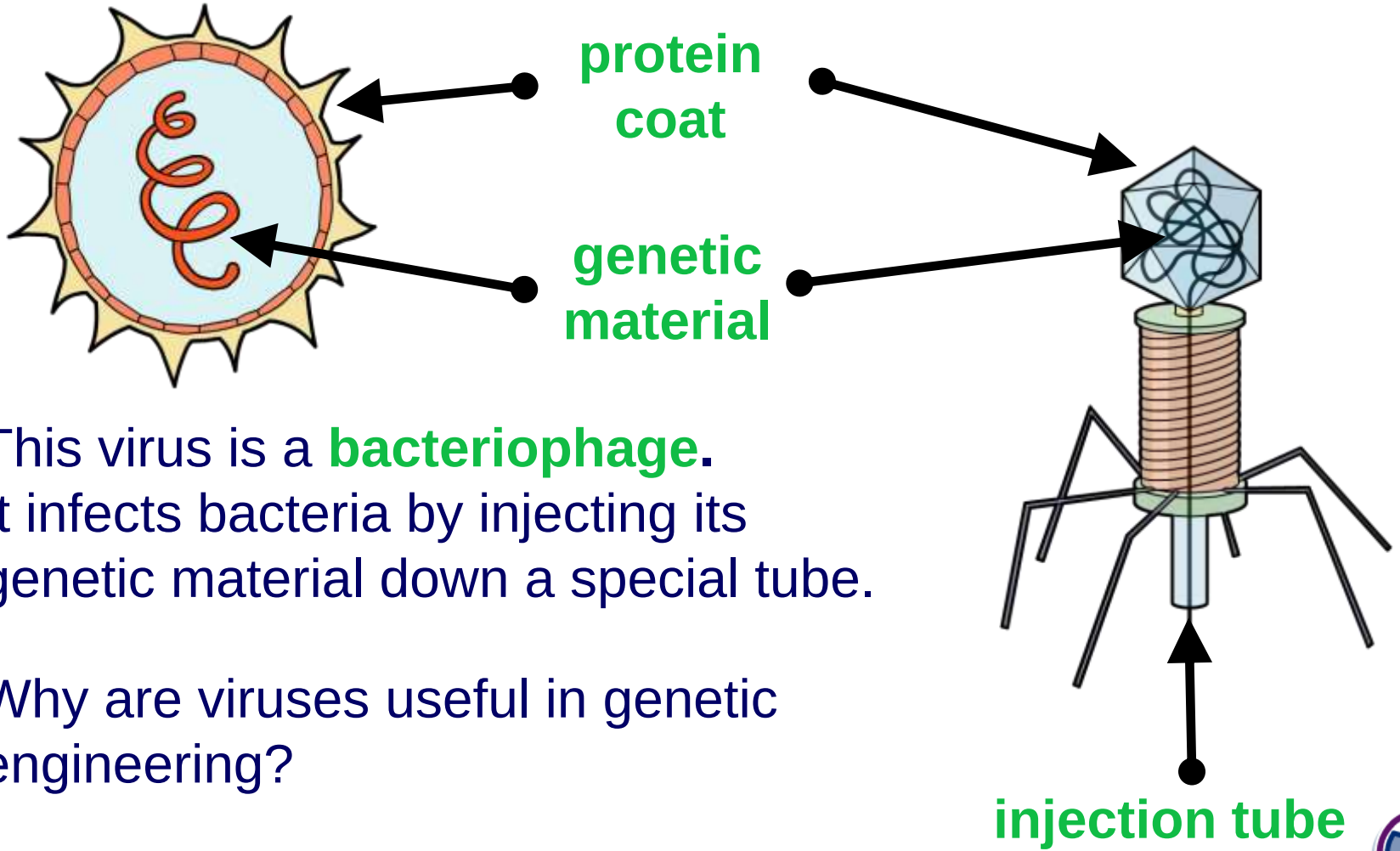
Bacteria are often genetically engineered to produce useful chemicals because their DNA is loose in the cytoplasm, making it easy to modify. They also grow and replicate quickly.



A new gene can be inserted into the **plasmid** and the bacteria then produce the protein that the gene codes for.

Using viruses

A virus cannot read its own genes but it can make a host cell copy them and make the proteins.



This virus is a **bacteriophage**.
It infects bacteria by injecting its genetic material down a special tube.

Why are viruses useful in genetic engineering?

Replicating micro-organisms

Genetically-engineered micro-organisms, such as bacteria and yeast, can easily be replicated on a large scale.

Tanks called **fermenters** or **bioreactors** are used. These enable the micro-organisms to be grown, or ‘cultured’, at optimum pH, temperature and nutrient levels.

The product can be continuously removed and purified.

Producing insulin with bacteria

How can bacteria produce human insulin?

Bacteria can be genetically engineered to produce human insulin.

Click "**start**" to find out how.

start

Genetically-engineering bacteria

What is the sequence of events in making bacteria produce a human protein?

1. The modified plasmid is inserted into the bacterium.
2. The gene for the human protein is identified.
3. A bacterial plasmid is cut open with enzymes.
4. The bacterium is added to a fermenter and replicates.
5. The gene is removed with enzymes.
6. The gene is inserted into the plasmid.
7. The bacteria produce the required protein.

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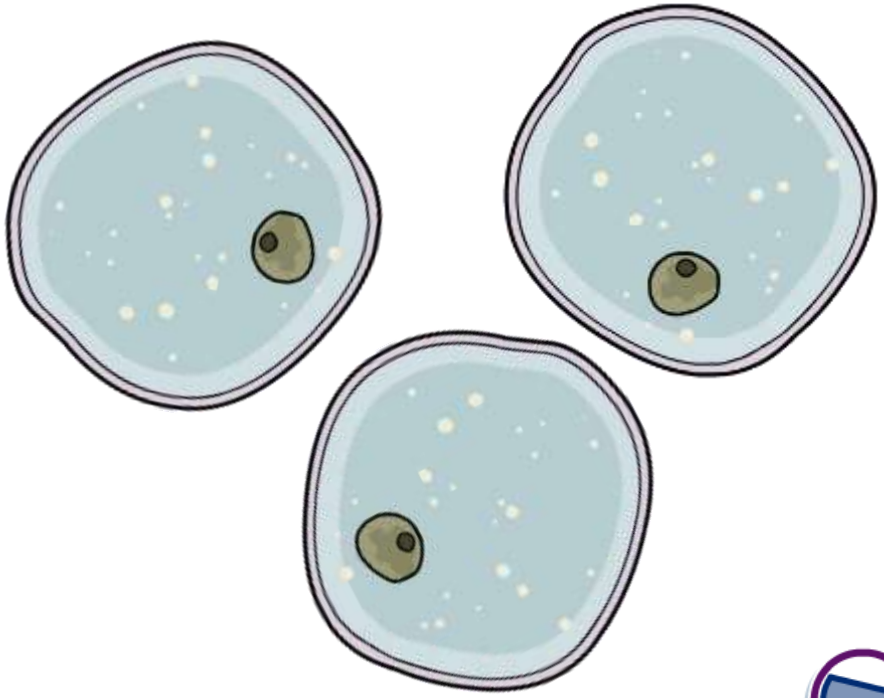
C solve

Alternatives to bacteria

Genetically-engineered bacteria are unable to make proteins that are identical to those found naturally in humans, despite having human DNA.

This is because the *way* in which bacteria make proteins is different to the way that mammals make proteins.

A better way is to use genetically-engineered **mammalian cells** grown in industrial bioreactors. These produce proteins that are identical to the ones found in humans.



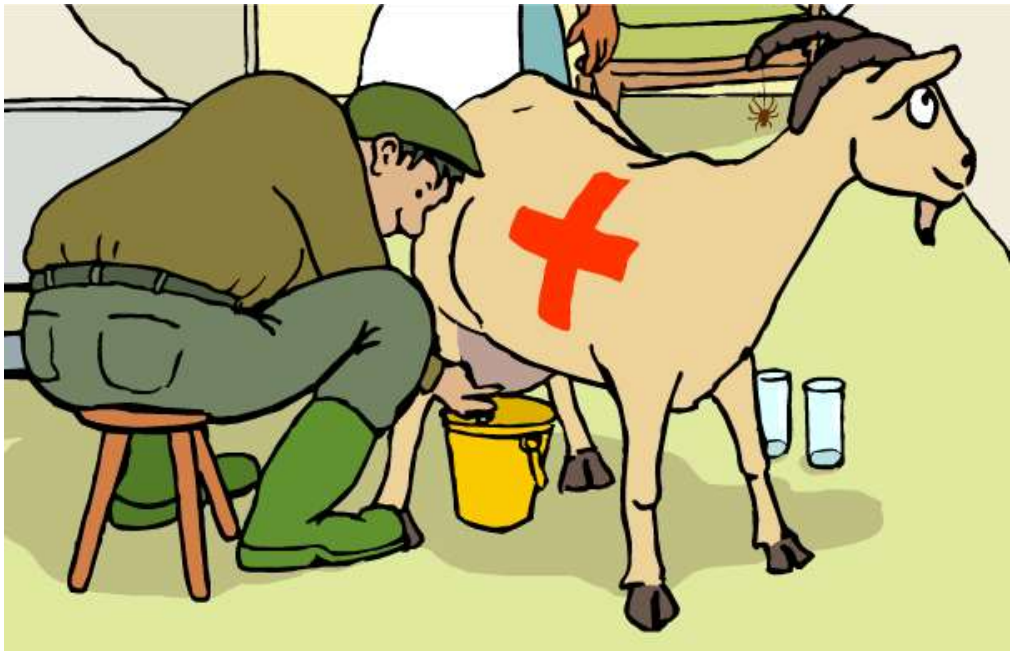
Genetic engineering and medicines

How can animals be genetically engineered to help humans?

What is transgenics?

Foreign DNA, including DNA from humans, can be inserted into animals. This is called **transgenics**.

The protein encoded by the DNA can then be produced in a specific tissue of the transgenic animal at a specific time.



This method produces higher levels of antibody, more easily and cheaply, than by using genetically-engineered bacteria or mammalian cells.

Transgenic goats

For example, the gene for a human antibody can be introduced into goats.

Additional controlling DNA is also introduced, so the human antibody is only produced in the goat's mammary gland at a certain time.

The antibody is then expressed in the goat's milk, where it can be purified and can used to treat diseases.

Which came first?

The eggs of this transgenic chicken contain a human antibody that could one day help to treat skin cancer.

What advantages does this method of producing antibodies have?

Do you think it is right for animals to be genetically engineered to help treat human diseases?

Genes and Genetic Engineering

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A new baby

This boy got half of his genes from his mother and half from his father.

It's completely random which ones he received. He may have his parents' best characteristics or their worst.

Are there any characteristics you wouldn't want your children to inherit?

Unlucky?

Sally has breathing difficulties. Her genes gave her **cystic fibrosis**. She risks repeated chest infections and lung damage.

Molly could be fine, but one of her genes puts her at risk. She has a high chance of getting **breast cancer**. Some women with the gene choose to have their breasts removed.

Designer babies: fact or fiction?

Total control of a person's genes only exists in science fiction, but it is currently possible to:

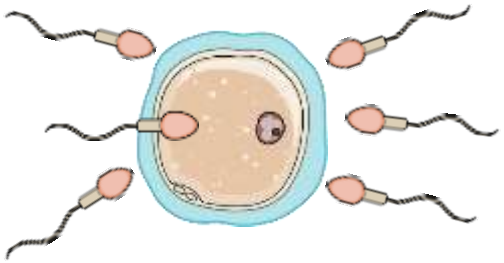
- screen embryos for genetic diseases – this is called **pre-implantation genetic diagnosis (PGD)**
- screen embryos for the right number of chromosomes – this is called **pre-implantation genetic screening (PGS)**
- screen embryos for their sex – some genetic diseases only affect boys, and in the UK, parents at risk of having a baby with a disease can choose to have a girl
- repair body cells containing faulty DNA by **gene therapy**.

In the future, it may be possible to replace an embryo's faulty DNA. This is **germ-line therapy** and is illegal in humans.

Pre-implantation genetic diagnosis

Aborting an embryo can be very distressing, even if it would have been born with a disease. PGD removes this problem.

1. The woman's eggs are fertilized in a 'test tube'.



2. The embryos develop and one cell is removed from each to be tested for certain genetic diseases.

3. Up to two healthy embryos are implanted in the mother's uterus.

Saviour siblings

Imagine your daughter has a rare genetic disease. An injection of bone marrow cells will save her but the donor must be an exact match.

Donors are hard to find. Your best hope is to make your next child a match.

You will need to produce a selection of embryos by **IVF**. The best embryo will become your next child. A few cells from its umbilical cord will save the daughter you already have.

More and more couples are asking for this treatment but should it be allowed?

Should saviour siblings be allowed?

Should parents be allowed to have saviour siblings?

These people have been asked if they think that parents should be allowed to choose the genetic make-up of their next child to save the life of an existing child with a serious illness.

Click on each person to find out their opinion.






What is gene therapy?

Children with faulty immune systems have been cured by adding genes to their bone marrow cells. This is called **gene therapy**.

1. A ‘healthy’ version of the faulty gene is cut from normal DNA and copied.

2. The gene is added to a harmless virus.

3. The virus carries the gene into the patient’s cells, where the healthy gene is released.

4. The patient’s cells can then make the correct product of the gene. The patient is then cured.

Carrying out gene therapy

Vectors are required to transfer the healthy genes used in **somatic cell gene therapy** into the body cells affected by the condition that is being treated.

Click the buttons to find out more about the two main types of vectors that are used.

liposome

viral vector

Genes and Genetic Engineering

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Glossary

- **base –** The chemical in DNA that forms the basis of the genetic code.
- **chromosome –** A long molecule of tightly coiled DNA found in the nucleus of most cells.
- **DNA –** The molecule that contains the genetic code.
- **gene –** The part of a chromosome that codes for a protein.
- **gene therapy –** Curing a genetic disease by replacing a faulty gene with a ‘healthy’ version.
- **genetic engineering –** Altering the characteristics of an organism by changing its genetic code.
- **transgenic –** An organism that contains DNA from a different type of organism.

Anagrams

How quickly can you unscramble anagrams of words about

g e n e s a n d

g e n e t i c

e n g i n e e r i n g ?

start

Multiple-choice quiz