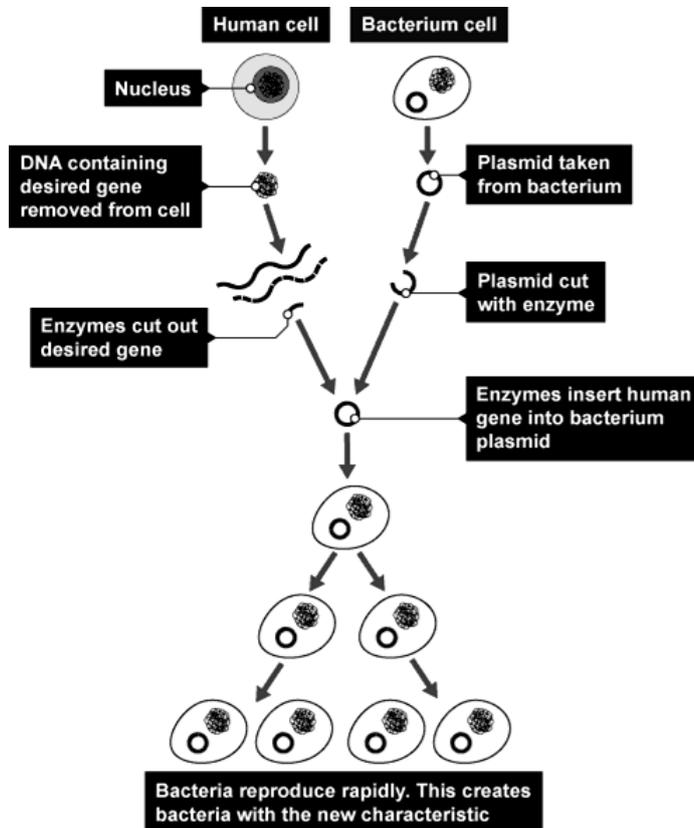


# GENETIC MODIFICATION AND CLONING

Genetic modification transplants genes for a desired characteristic into a different organism. Cloning makes an identical genetic copy of a parent plant or animal.



## Genetic modification

Genetic modification (GM, also called genetic engineering) involves taking a gene from one species and putting it into another species. It involves these steps:

1. selection of the desired characteristic
2. isolation of the gene responsible for the characteristic
3. insertion of the gene into another organism
4. replication of the transgenic organism

This diagram shows how it works:

## Genetic Modification - Uses In Medicine

### Making insulin

Diabetes is a disorder in which the body's blood glucose levels remain too low or too high. It can be treated by injecting insulin. The extra insulin allows the glucose to be taken up by the liver and other tissues, so cells get the glucose they need and blood glucose levels stay normal.

### GM insulin

Natural insulin can be taken from the pancreases of pigs or cattle. However, this insulin causes adverse reactions in some people and its supply is limited.

Nowadays, most insulin is made using genetically modified bacteria that have had the human gene for insulin inserted into them.

This GM insulin has some advantages over insulin taken from pigs or cattle:

- it can be made in very large amounts from bacteria grown in a fermenter
- it is less likely to cause an adverse reaction
- it overcomes ethical concerns from vegetarians and some religious groups

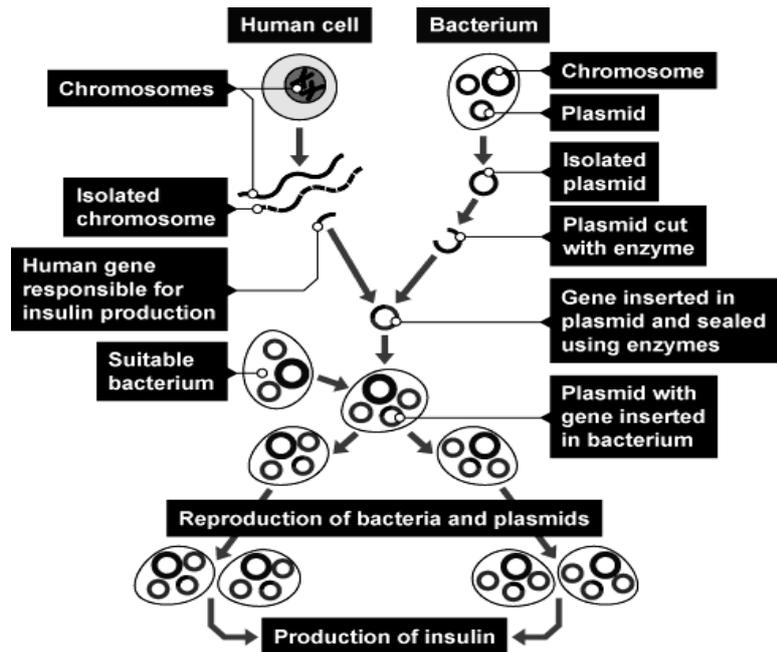
## Making GM insulin

Genetic modification needs a DNA vector and certain enzymes. Vectors take pieces of DNA and insert them into other cells. Viruses and plasmids can act as vectors.

Restriction enzymes cut DNA at specific sites, rather than just in random places along the DNA molecule. Similarly, ligase enzymes join pieces of DNA together at specific sites.

GM insulin is produced in the following way:

1. the gene for making insulin is cut from a length of human DNA using restriction enzymes
2. it is inserted into a plasmid using ligase enzymes.
3. the plasmid goes into a bacterial cell
4. the transgenic bacterium reproduces, resulting in millions of identical bacteria that produce human insulin



## GM Crops

Genetic modification can be used to produce plants that improve food production. For example, a plant may be produced with improved resistance to pests.

However, there are ethical issues involved in genetic modification. There are concerns about the possible health risks of genetically modified food. For example, a GM food might contain a substance that causes an allergic reaction in some people, or higher levels of a toxin naturally found in the food. Others think it is morally wrong to create new life forms, or to move genes between different species.

## Golden Rice

Scientists have added a gene to wild rice that makes it produce beta carotene. This changes the colour of the wild rice to a golden colour. Beta carotene is needed by humans in order to make vitamin A - which is essential for good vision.

The advantage of golden rice is that it can be used in areas where vitamin A deficiency is common, so it can help prevent blindness.

However, there are also disadvantages. For example:

- beta carotene levels in golden rice may not be high enough to make a difference
- there are fears that it will cross-breed with and contaminate wild rice
- there are concerns that food from GM plants might harm people
- seed for GM plants can be expensive

## Herbicide-Resistant Crops

Scientists have added genes to crop plants that make them resistant to herbicides. This means that less herbicide needs to be used. However, there are disadvantages to creating these plants. For example:

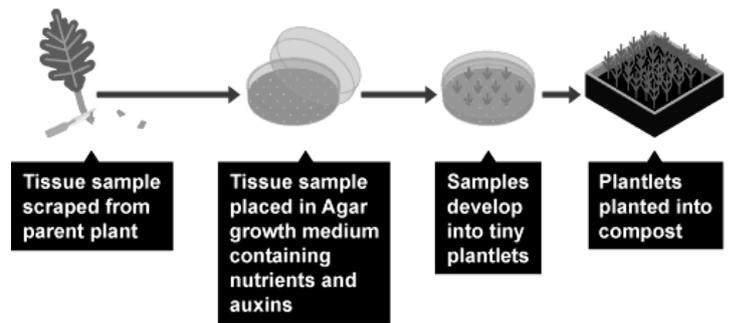
- the potential development of herbicide-resistant weeds
- loss of biodiversity because fewer weeds survive - resulting in reduced food and shelter for animals

## Cloning Plants

Clones are genetically identical individuals. The cloning of plants has many important commercial implications. It allows a variety of a plant with desirable characteristics to be produced cheaply, quickly and on a large scale.

## Cuttings

The simplest way to clone a plant involves taking a cutting. A branch from the parent plant is cut off, its lower leaves are removed, and the stem is planted in damp compost. Plant hormones are often used to encourage new roots to develop. The cutting is usually covered in a clear plastic bag to keep it moist and warm. After a few weeks, new roots develop and a new plant is produced. This method is easy enough for most gardeners to do successfully.



## Tissue culture

Another way of cloning plants is by tissue culture, also called micropropagation. It works with small pieces of plants, called explants. These are grown in vitro using sterile agar jelly that contains plant hormones and nutrients. This makes tissue culture more expensive and difficult to do than taking cuttings.

### Method for tissue culture:

1. take explants from the parent plant
2. transfer to plates containing sterile agar jelly
3. add plant hormones to stimulate the plant cells to divide
4. cells grow rapidly into small masses of plant tissue
5. add more plant hormones to stimulate the growth of roots and stems
6. transfer the plantlets into potting trays, where they develop into plants

## Cloning Mammals

The cloning of animals has many important commercial implications. It allows an individual animal with desirable features, such as a cow that produces a lot of milk, to be replicated several times. But the process takes much longer than it does with plants.

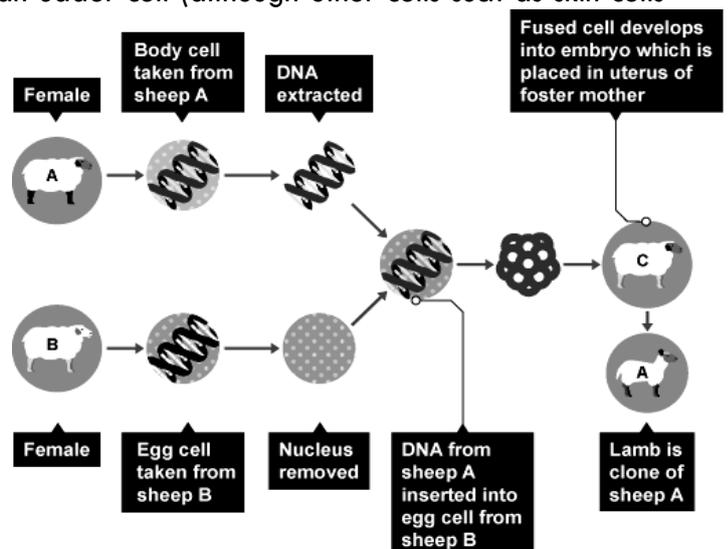
### Dolly the sheep

Dolly the sheep was the first mammal to be cloned. She was born in the UK in 1996 and died in 2003. She was produced using the nucleus from an udder cell (although other cells such as skin cells may also be used).

The stages of cloning a mammal include:

1. removal of diploid nucleus from a body cell
2. enucleation - removing the nucleus from an egg cell
3. insertion of the diploid nucleus into the enucleated egg cell
4. stimulation of the diploid nucleus to divide by mitosis

The new animal is genetically identical to the animal that donated the nucleus from one of its body cells.



The cloning process used to produce Dolly the sheep

## GM And Cloning Compared

Genetic modification and cloning are not the same thing. Although cloning techniques are used in genetic engineering, they should not be confused. The table shows some of the differences.

Cloning	Genetic Modification
Produces exact copies of an organism	Produces a single new organism
Genes copied within the same species	Genes can be swapped across species

### Genetic modification

There are benefits to producing transgenic animals and plants. For example:

- sheep that produce human proteins for treating cystic fibrosis
- animals that produce commercial quantities of human antibodies
- tobacco plants that glow in the dark when they need watering

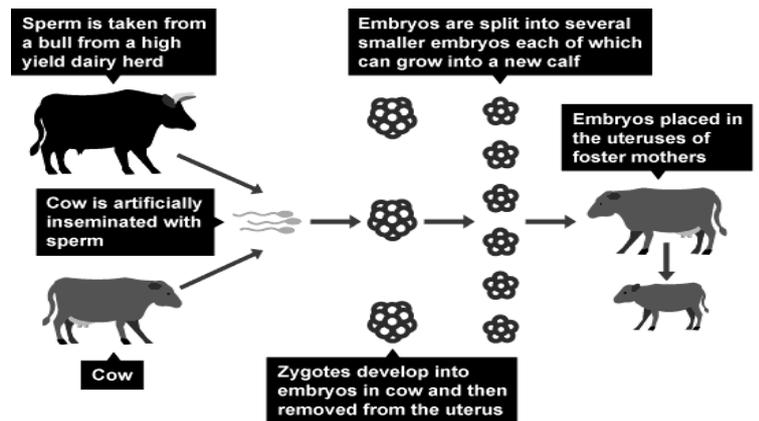
Some people are excited by the almost limitless possibilities of genetic engineering, while some people believe the process is unethical and should be banned.

Others are concerned about what might happen in the future. For example, mice containing human genes and chromosomes have already been produced. Where will this lead us in the years ahead?

### Cloning

Cloning expensive food crops has been carried out for many years, and causes the public fewer ethical and moral concerns than animal cloning. Cloning often follows genetic modification. It allows many copies of the transgenic organism to be produced.

Animal cloning raises ethical issues about how far humans should be allowed to interfere in the production of new life. Regulations currently restrict scientific research into human cloning.



*Cloning cows using embryo transplant*

### Stem Cells

During the development of an embryo, most of the cells become specialised. Their structure develops to match their function, and they cannot later change to become a different type of cell. However, stem cells are unspecialised cells that can grow into any type of cell found in the body.

There are two types of stem cells:

- adult stem cells - these can develop into many (but not all) types of cell
- embryonic stem cells - these can develop into any type of cell

Adult stem cells come from tissues such as bone marrow and the lining of the small intestine. Human embryonic stem cells can be removed from unused embryos left over from fertility treatment, for example.

### Uses of stem cells

Stem cells can be used in different ways. For example, they can:

- make new brain cells to treat people with Parkinson's disease
- rebuild bones and cartilage
- repair damaged immune systems
- make replacement heart valves

Although stem cells have considerable potential in medical treatments, there are significant social and ethical issues concerning the use of human embryonic stem cells in medical research and treatments.

## QUIZ

### Tick the right answer

1. **What sort of organisms can be genetically modified?**
  - a) Plants only
  - b) Animals only
  - c) Plants and animals
2. **Which statement about enzymes involved in genetic modification is correct?**
  - a) Restriction enzymes join pieces of DNA together
  - b) Restriction enzymes cut DNA at specific sites
  - c) Ligase enzymes cut DNA at specific sites
3. **Which vectors can be used in genetic modification?**
  - a) Viruses and plasmids
  - b) Viruses only
  - c) Plasmids only
4. **How was 'Dolly the sheep' produced?**
  - a) By genetic modification
  - b) By cloning
  - c) By genetic modification followed by cloning
5. **What is an explant?**
  - a) Part of a gene in a DNA sequence
  - b) A small piece of plant used in micropropagation
  - c) A vector used in genetic modification
6. **What is one advantage of producing plants by tissue culture?**
  - a) All the plants produced will be susceptible to the same diseases
  - b) New varieties are produced, depending on which nutrient medium is used
  - c) Genetically identical plants with desirable characteristics can be produced
7. **What is an enucleated cell?**
  - a) A cell with two nuclei
  - b) A cell with no nucleus
  - c) A cell with a normal nucleus
8. **What type of nucleus is used in cloning a mammal?**
  - a) A haploid nucleus
  - b) A diploid nucleus
  - c) A mitosis nucleus
9. **What does transgenic mean?**
  - a) The transfer of genetic material from one species to a different species
  - b) Having extra copies of chromosomes in the nucleus of the cell
  - c) The production of genetically identical organisms by asexual reproduction, such as growing cuttings from a plant
10. **The nucleus from an udder cell is taken from sheep A. It is put into an egg cell from sheep B that has no nucleus. This cell is then put into a host mother, sheep C. Which statement about the resulting lamb is correct?**
  - a) The lamb is a clone of sheep A
  - b) The lamb is a clone of sheep B
  - c) The lamb is a clone of sheep C

### Match words from A with their definition in B

A	B	
1. Agar jelly	The way in which genetic material is transferred from a donor to a recipient, e.g.: viruses, bacterial cells or plasmids.	1 + ...
2. Diploid	A cell found in foetuses, embryos and some adult tissues that can give rise	2 + ...

nucleus	to a wide range of other cells.	
3. Embryo	Describes an organism that has undergone genetic modification and has had genes transferred from another unrelated organism.	3 +...
4. Enucleation	A gel made from algae, which provides an ideal growth medium.	4 +...
5. Explants	An organism in the early stages of development.	5 +...
6. Fermenter	An enzyme that can join pieces of DNA together.	6 +...
7. Herbicide	Tissue culture is the growth of tissues or cells separate from an animal or plant.	7 +...
8. In vitro	The process of removing the nucleus from a cell, which produces an 'enucleated cell'.	8 +...
9. Ligase	A small piece taken from a plant, used in plant cloning.	9 +...
10. Plasmid	A substance used to kill weeds.	10 +...
11. Restriction enzyme	Experiments done in glassware such as test tubes and Petri dishes.	11 +...
12. Stem cell	The small circular genetic material present in bacterial cells and used in genetic engineering or genetic modification	12 +...
13. Tissue culture	A tank containing nutrients, which is used to grow large numbers of bacteria or yeast.	13 +...
14. Transgenic	A nucleus that contains pairs of chromosomes, giving it the full number of chromosomes.	14 +...
15. Vector	An enzyme that can cut DNA in specific places in the DNA molecule.	15 +...

## GRAMMAR

Linking words and phrases join clauses, sentences and paragraphs together.

### Let's practice

Below are sentences with misused transition words. Cross out the incorrect transition words and write a better one

- Tim earned an A on the test; even so, Justin also received an A. \_\_\_\_\_
- The book was interesting; as a result, it was hard to read. \_\_\_\_\_
- Gordon finished his chores early; meanwhile, he had time to play football \_\_\_\_\_
- Sarah's horse is beautiful; instead, it is well-bred. \_\_\_\_\_
- Her sister had a cold; however, Julie's family canceled the trip. \_\_\_\_\_
- Oranges are good for you; nevertheless, they are full of vitamin C. \_\_\_\_\_
- Two seats were left on the bus; similarly, most of the group had to wait for the next one. \_\_\_\_\_

Circle the letter that correctly identifies the nature of the underlined transition in each of the following sentences.

- A water main downtown broke this morning, so several businesses had no water for hours.  
a. addition      b. time      c. comparison      d. cause and effect
- Even though most Americans are primarily concerned about AIDS as it exists in the U.S., it should be remembered that it is now nearly a worldwide disease.  
a. addition      b. time      c. contrast      d. comparison
- There are ways you can make boring tasks more pleasant. For instance, bring a portable radio and listen to music on the earphones while you work.  
a. contrast      b. comparison      c. illustration/example      d. cause and effect

4. Science-fiction writer Arthur C. Clarke correctly predicted that satellites would be used for communication. Moreover, in 1947 he correctly predicted that 1959 would be the year the first rocket to the moon was launched.

- a. **addition**                      b. **time**                      c. **contrast**                      d. **cause and effect**

5. Some people in New Jersey built their houses very close to the shoreline. Consequently, they have had to spend a lot of money trying to protect their property from the sea.

- a. **addition**                      b. **contrast**                      c. **illustration/example**                      d. **cause and effect**

6. Running can make people more aware of their physical surroundings, such as the scent of honeysuckle or the changing moods of the trees.

- a. **addition**      b. **contrast**                      c. **illustration/example**                      d. **cause and effect**

**Read each sentence below and choose the correct transition word.**

1. One reason people have dogs is for companionship; \_\_\_\_\_ is for protection

Transition words:	once	frequently	another
The transition indicates:	illustration	addition	conclusion

2. \_\_\_\_\_ the invention of television, people probably spent more of their leisure time reading.

Transition words:	Nevertheless	Because	Before
The transition indicates:	addition	cause and effect	time

3. If you're having company for dinner, try to get as much done in advance as possible. \_\_\_\_\_, set the table the day before.

Transition words:	For instance	In contrast	Similarly
The transition indicates:	illustration/example	comparison	contrast

4. \_\_\_\_\_ I'm very allergic to flowers, my boyfriend bought a bouquet of roses.

Transition words:	Until	Because	Even though
The transition indicates:	time	contrast	addition

5. My grandfather loves to say, "You're as nervous \_\_\_\_\_ a long-tailed cat in a roomful of rocking chairs."

Transition words:	after	as	as a result
The transition indicates:	cause and effect	time	comparison

6. \_\_\_\_\_ Manny's car stereo was on full blast, I could see his lips moving, but I had no idea what he was saying.

Transition words:	Just as	Moreover	Because
The transition indicates:	comparison	addition	cause and effect

**Use the words in the bank to connect the clauses below. You should only use a transition word or phrase once.**

**Word Bank**

**In addition**  
**Otherwise**  
**Although**  
**Therefore**  
**In fact**  
**Furthermore**  
**Similarly**  
**Consequently**  
**Actually**  
**So**  
**However**  
**Nevertheless**  
**Yet**  
**Instead**  
**Moreover**  
**Particularly**

1. The girls wanted an ice cream cone, \_\_\_\_\_ they left the park early.
2. Mother didn't have time to go to the store; \_\_\_\_\_, there was no milk in the refrigerator.
3. There is no homework tonight; \_\_\_\_\_, there has been no homework this week.
4. James and his team didn't finish the project; \_\_\_\_\_, they did work hard.
5. You can come with us if you are ready; \_\_\_\_\_, you will have to ride the bus.
6. It is important to complete your homework; \_\_\_\_\_, it should be turned in on time.
7. Mrs. Simpson can be grumpy some times; \_\_\_\_\_, we should help her whenever we can.
8. Students should be quiet during the play; \_\_\_\_\_, applause at the end is allowed.
9. The Johnson children get an allowance every week; \_\_\_\_\_, they earn money for completing chores.
10. The rhino in Africa is threatened with extinction; \_\_\_\_\_, many species of gorilla are also endangered.