Variation

Learning objectives

- ❑ Describe how the genome and its interaction with the environment influence the development of the phenotype of an organism.
- ❑ Know that difference in the characteristic of individuals is called variation
- ❑ Know that usually there is extensive genetic variation within a species
- ❑ Know that all variants are due to mutations and that must have no effect on phenotype, some influence phenotype, very few determine phenotype.
- ❑ Know mutations happen all the time, and that is rare that a mutation will lead to a new phenotype and if that phenotype is better suited to an environment change it can lead to rapid changes in the species.

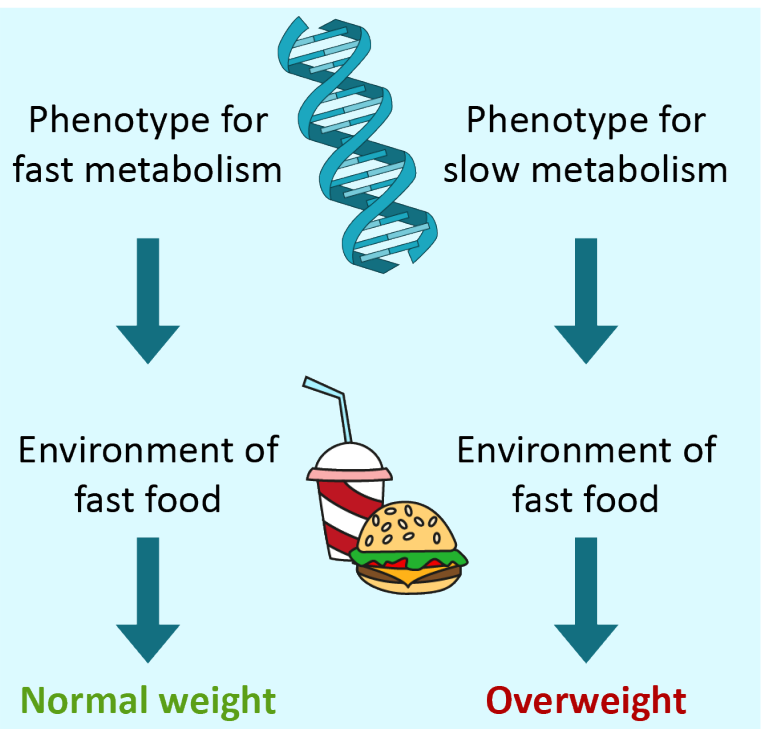
Phenotype

Phenotype refers to the **observable physical properties** of an organism. This includes appearance, development, behaviour and even functioning of internal systems. For example, eye colour is a phenotype but so is metabolism.

The phenotype is dependent on **both** the **genotype** and the **environment**. The genotype is the **genes** an organism has **inherited**. For example, you may have inherited brown eyes from your mum and not your dad's green eyes. Every **living thing** has a **unique genotype**, except twins and clones.

The **environment** also affects **phenotype**. For example, in group clownfish, when the only female dies, a male will change its sex to female to replace her. This is a change in phenotype due to **a change in the environment**. The genes of the fish have not changed – just which ones are being used. Another example is the colour of flamingo's feathers. The pink comes from what they eat!

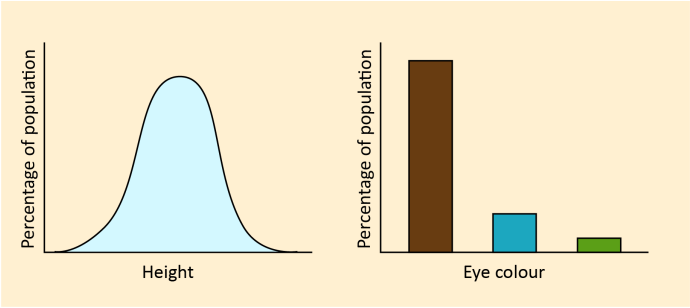
Lots of characteristics are **influenced** by **both** the **environment** and the **genotype.** For example, height and weight. Your **maximum height** is dependent on your **genes**. However, if you do **not** get enough food during growth spurts, you will **not reach** your genetically determined maximum height. Weight is another example; it depends on **what you eat**. However, it also depends on your **metabolism** – how fast your body breaks down and uses energy from food. The speed of your metabolism is **dependent on your genotype**.



Variation

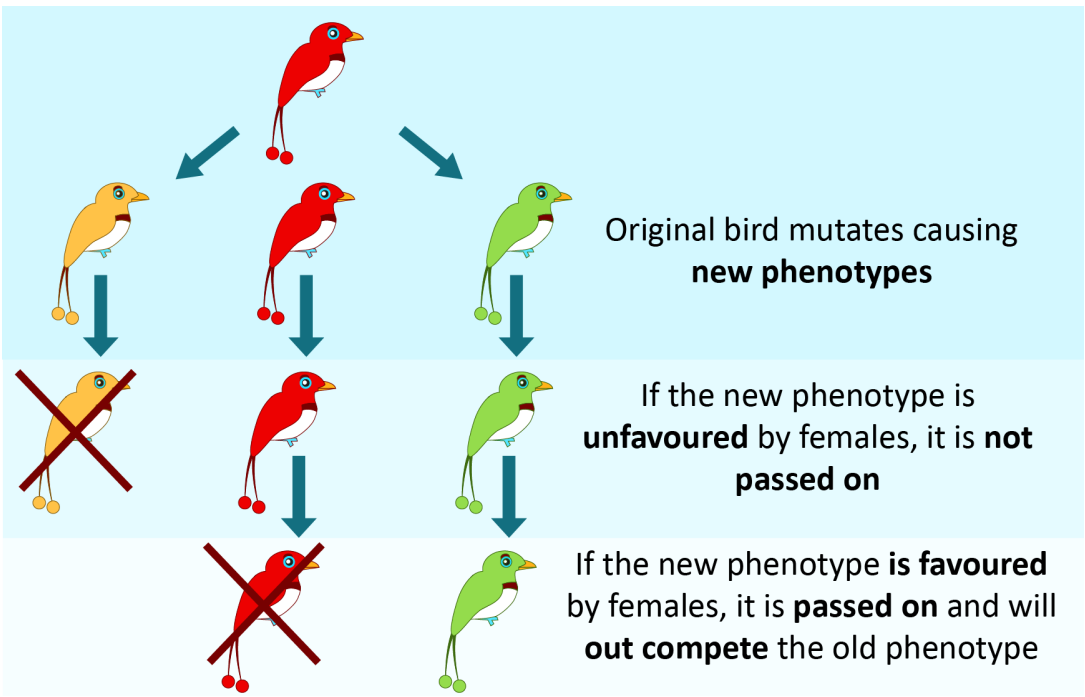
Genetic variance

Genetic variance refers to the **natural** differences in the **genotype** of a population of a species. There is usually an **extensive genetic variation** within a species, just think how different dogs can look! Genetic variation is a **good thing**. It allows for the potential of **better adaption** to the environment, while **preserving** the species as a whole. There are **two types** of genetic variance, **continuous,** like height or **discontinuous**, like eye colour.



Genetic differences are due to **random mutations**. Mutations are **happening all the time**. Every time a human cell replicates about ten new mutations occur. Luckily, most mutations **do not affect phenotype** and pass unnoticed. Some will **influence phenotype** but will not cause a new phenotype. On **rare** occasions, a mutation occurs that does **create a new phenotype**. If this new phenotype is **better suited** to the environment the species is in, the species will **quickly adapt**, and it will become the **common phenotype**.

For example, birds of paradise are very colourful birds, the females choose their partner based on their colours and dances. If a **mutation occurred** that caused a new pattern or colour, and the females **preferred** it – the new colour or pattern would **spread through the population**. This is because the bird with the new colour would **breed more.**



Selective breeding

Learning objectives

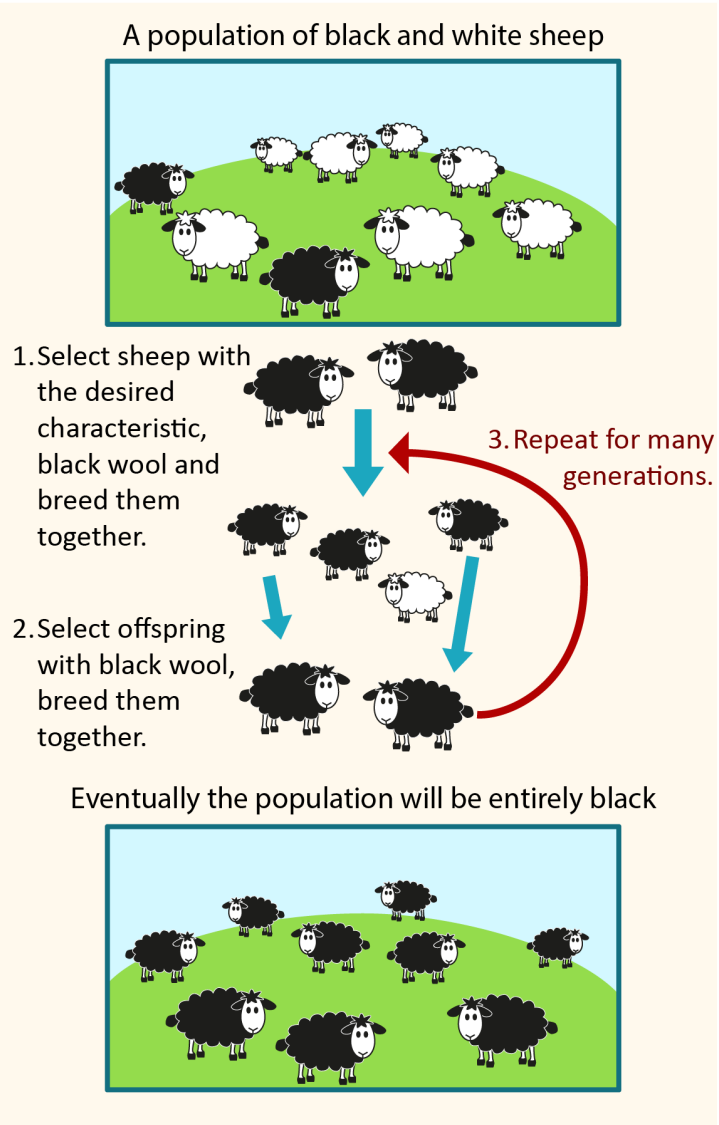
- ❑ Define selective breeding
- ❑ Explain the impact of selective breeding on crops and domesticated animals, and that it has been happening for thousands of years
- ❑ Understand and describe the process of selective breeding
- ❑ Know some examples of what characteristics are selectively bred for
- ❑ Selective breeding can lead to 'inbreeding' where some breeds are particularly prone to disease or inherited defects

Selective breeding

Selective breeding is the process by which **humans** breed plants and animals for **particular genetic characteristics**, that are rare in their wild ancestors and are **beneficial** to humans. It is sometimes known as artificial selection (rather than Darwin's theory of natural selection). Selective breeding has been around for **thousands of years** since humans **domesticated wolfs**, and used and **breed wild plants as crops.**

Selective breeding takes **many generations** of breeding. The main steps are:

1. **Choose** a desired characteristic
2. Find **parents** that have this desired characteristic and **breed** them together.
3. From the **offspring, choose** more breeding pairs that have the **desired characterise**.
4. **Repeat** over many generations until all offspring show the desired characteristic.



Desired characteristics can include:

Animals

- The colour, length and texture of fur
- Produce large amounts of product, such as eggs and milk
- The size of the animal

Plants

- Disease and pest resistance
- Produce large amounts of product, such as grains and fruits
- Taste
- Large or unusual flowers

Selective breeding

Benefits and risks of cloning

Benefits

- New varieties produce **more** or **better products**, leading to more profit.
- Animals can be selected to **reduce harm**, such as breeding cows with no horns or tame wolfs (that eventually leads to dogs).

Risks

- Inbreeding can:
  - **Reduce** the **genetic variance** can lead to weaknesses to specific pests and diseases.
  - **Accidently** select for **rare diseases** then selecting another positive trait, for example, large dogs are prone to bone cancer.
  - **Create physical problems** in the species, for example, pugs have trouble breathing.

Case study

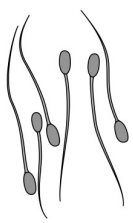
In 1959 Dmitry Belyaev started **selective breeding foxes**. Scientists choose foxes that were **least afraid of humans**. In just **ten** generations of being the foxes became **tame**. They sort **attention** from people and even **wagged** their tails.

However, although this was the desired change, it was not the only change. The foxes begun to **look different**, developing **curly tails**, **spotted coats** and **puppy-like ears**. Although it is difficult to say that these foxes became domesticated, they were definitely changed by the selective breeding.

Worked exam questions

Bull sperm cells contain a different number of chromosomes to the number in body cells.

Bull **skin** cells contain 60 chromosomes.



(a) What is the **haploid** number of chromosomes for a bull?

30 [1]

(b) The Holstein breed of cattle has been bred especially for milk production.

Many Holstein cattle frequently suffer lameness and diarrhoea.

This is because of the way they are bred.

Explain why the method of breeding can increase the risk of lameness and diarrhoea.

Holstein cattle are selectively breed for. This leads to inbreeding, reducing genetic variance. Lameness + diarrhoea must be caused by reduced genetic variance [3]

Genetic Engineering

Learning objectives

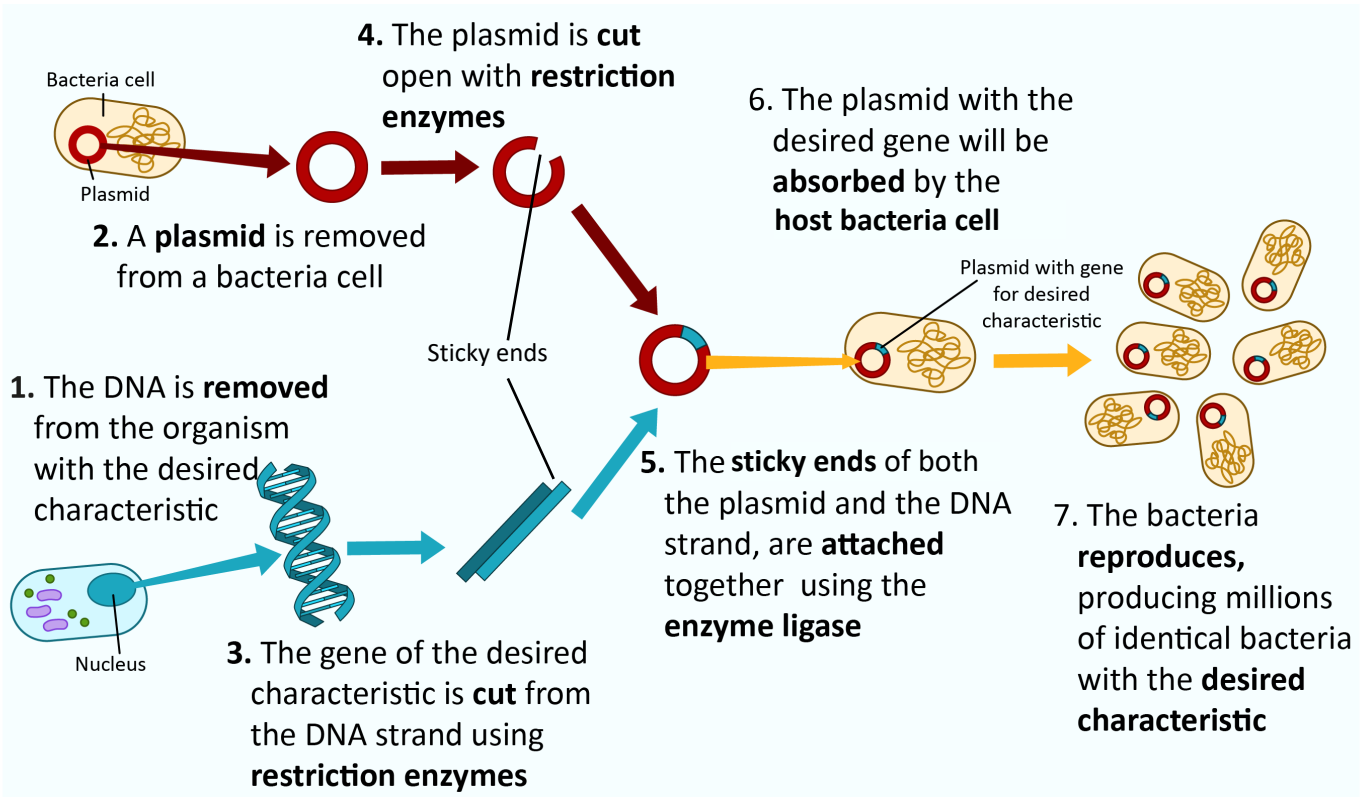
- ❑ Describe the process of genetic engineering, including the terms; vector, host bacterium, restriction enzymes, ligase, sticky ends
- ❑ Genetic engineering takes place at the early development of the host organism so they will develop the desired characteristic
- ❑ Know that some plant crops have been genetically modified to be resistant to disease or produce bigger yields and that they are known as GM crops
- ❑ Know that bacteria have been genetically modified to produce insulin
- ❑ Explain the potential benefits and risks of genetic engineering
- ❑ Modern medical research is exploring the possibility of genetic modification in some inherited disorders

Method

Genetic engineering (sometimes known as genetic modification (GM)) is a process that **modifies** the **genome** of an organism, by **inserting a gene** with a desired function or outcome, into the organism.

Genetic engineering requires:

- **DNA vector** – this a DNA molecule, normally a **virus** or a **plasmid** that is used to **carry** a foreign genetic material into another cell.
- **Restriction enzymes** - **cut** DNA at specific sites
- **Ligases enzymes** – **join** DNA at specific points
- **Sticky ends** – the **cut ends** of the gene and vector
- **Host bacterium** – a bacteria that **absorbs** the new gene



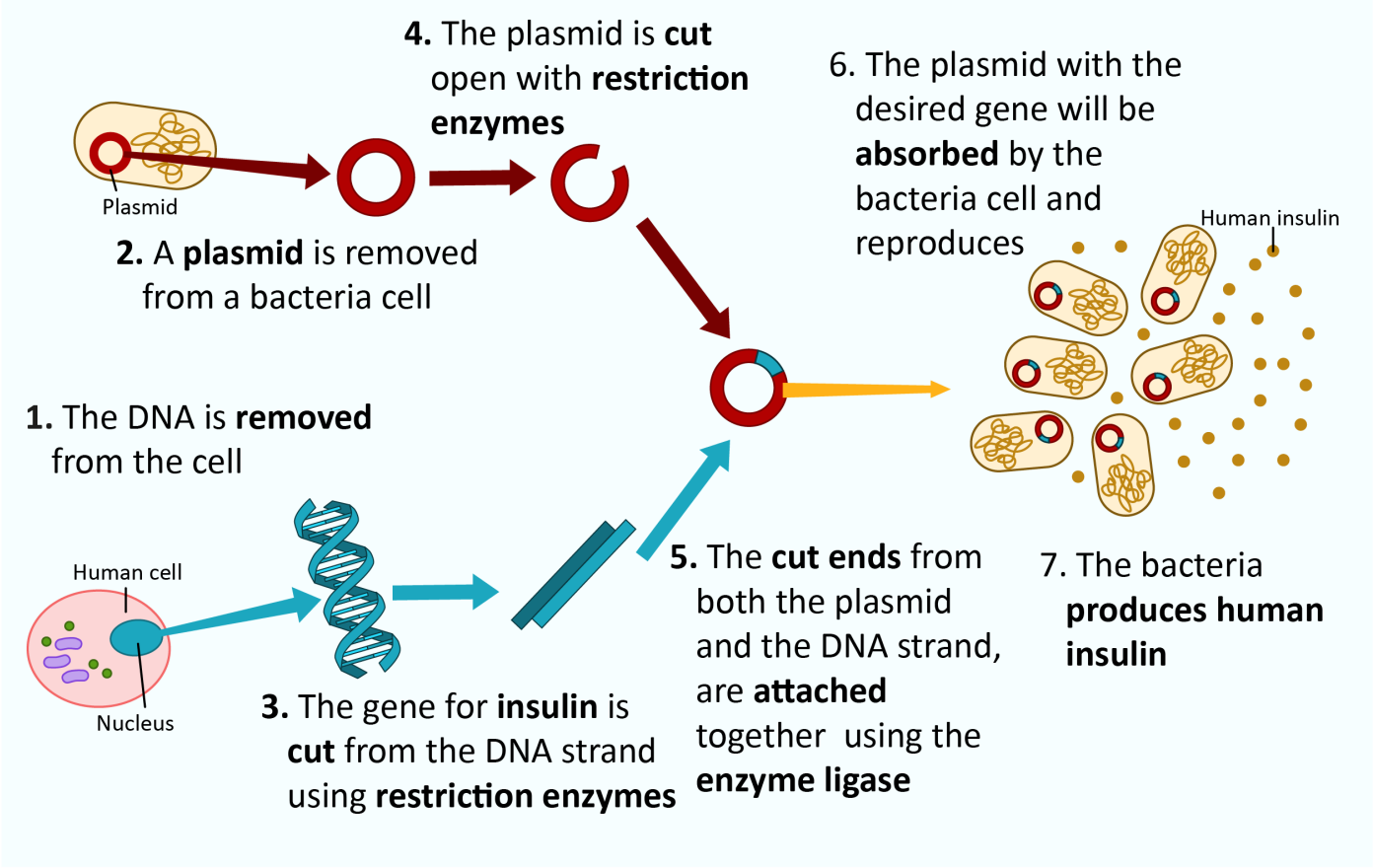
Genetic Engineering

Insulin

Insulin is a hormone that helps **monitor glucose levels** in the blood. In **type 1 diabetes**, the body **cannot** produce insulin and blood levels can get **dangerously** high or low. However, people with diabetes can **inject** themselves with insulin.

Genetically engineered bacteria can produce **human insulin**. The genetically engineered bacteria is made by **inserting the gene** for **human insulin** into the bacteria. The GM bacteria will **produce it** and then secrete it.

Making GM insulin



Before we could genetically modify organisms, people with diabetics had to use insulin from **pigs or cattle**. Using genetic engineering has allowed substantial amounts of insulin to be made **cheaply**. Because the insulin produced is **human insulin** rather than animal, it is **less** likely to **cause reactions**. And vegetarians or religious people have **no ethical problems** using it.

GM crops

Genetic engineering has been used to produce plants with **increased yield, nutrition** and **resistance** to some types of diseases, pests or herbicides. These crops are often referred to as **GM (genetically modified) crops.** However, GM crops might have **adverse effects** on **food-chains, decrease biodiversity** and **potentially harm humans**.

Genetic Engineering

Case study – Golden Rice

Scientists added the **beta carotene gene** to wild rice, to make golden rice. It is called golden rice as the beta carotene changes the colour of the rice to a gold colour. Beta carotene is **needed** in humans to make vitamin A, which is **essential for vision**. In some areas, people have vitamin A deficiency that **leads to blindness**. The idea of golden rice was to provide these people with an **easy source of victim A** and **prevent** blindness. However, there are some unknowns:

- The beta carotene levels **may not be high** enough to prevent blindness
- The golden rice might **cross-bread** with the wild type, contaminating it
- Many people are concerned that food from **GM crops might harm people**
- GM crops can be **patented**, and their seeds can be **expensive**

Benefits and risks

Benefits

- **Mass produces hormones** that are needed in medicine.
- It can **improve** crop **yields** by improving growth, allowing crops to grow in harsh conditions and make them resistance to herbicides, diseases and pests.
- **Extra vitamins** can be added to crops and grown where there are deficiencies.
- Greater yield could help **solve world hunger**.

Risks

- GM crops might affect the **growth of wildflowers**, and the **insects** that rely on them.
- Herbicides and pesticides **reduce biodiversity**.
- We do not know if GM crops will **affect human health**.
- People worry about the **ethics of altering nature**. If we genetically modify crops, could this not lead to genetically modifying humans?
- GM crops might **outcompete** their wild species, causing them to become rare.

Genetically engineering disease

Some **diseases** are caused by the **mutation** of a **single gene**. These diseases are typically **inherited** and affect the quality of life of the person who has it. In recent years, scientists have **developed gene therapy**. This involves transferring a **non-faulty version** of the gene into the **person**. Gene therapy has the potential to **cure many diseases**. However, there have been some **hurdles** to overcome; how to **target** the specific cells, **unknown side-effects** and finding a **reliable** way to get the genetic material into the cells. There has already **been some success** in clinical trials for haemophilia, leukaemia and a type of blindness caused by retinitis pigmentosa.

Genetic Engineering

Worked exam questions

Q7. Scientists have produced many different types of GM (genetically modified) food crops.

(a) Use words from the box to complete the sentence about genetic engineering.

clones	chromosomes	embryos	genes

GM crops are produced by cutting ..... genes ..... out of the ..... chromosomes ..... of one plant and inserting them into the cells of a crop plant.

(2)

(b) Read the information about GM food crops.

- Herbicide-resistant GM crops produce higher yields.
- Scientists are uncertain about how eating GM food affects our health.
- Insect-resistant GM crops reduce the total use of pesticides.
- GM crops might breed naturally with wild plants.
- Seeds for a GM crop can only be bought from one manufacturer.
- The numbers of bees will fall in areas where GM crops are grown.

Use this information to answer these questions.

(i) Give **two** reasons why some farmers are in favour of growing GM crops.

1 higher yeild - increase profits

2 less peshicides - reduces costs

(2)

(ii) Give **two** reasons why many people are against the growing of GM crops.

1 less bees - less pollinators for plants

2 unknown effects on heath

(2)
(Total 6 marks)

Genetic Engineering

1 Genetic engineering can be used to produce plants that are resistant to herbicide.

One herbicide works by preventing the activity of an enzyme.

Some bacteria have a form of this enzyme that is not affected by the herbicide.

(a) Suggest how genetic engineering can be used to produce plants resistant to this herbicide.

(3)

Using restriction enzymes cut out gene from bacteria, for coding the resistant enzyme. Insert gene into crop.

3 In 2011, South Korean scientists genetically engineered a cell from a beagle.

They then cloned this cell to create a beagle.

They called this beagle Tegon.

Tegon glows in the dark when UV light is shone on him.

© Dentistry Today

(b) To genetically engineer the original cell so that it would glow, the scientists had to obtain a suitable gene.

(i) Describe the stages that a scientist would complete to obtain this gene.

(2)

1. find a bachium with glowin gene
2. locate the gene in the DNA
3. Cut gene with restriction enzymes.

Cloning

Learning objectives

- Define the term clone, as two or more individual organisms that are genetically identical.
- Understand different methods of cloning and when they are used:
  - tissue culture;
  - cuttings;
  - embryo transplants;
  - adult cell cloning.

Cloning

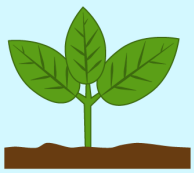
Clones are two or more **individual organisms** that are **genetically identical**. Cloning **plants** is useful for **commercial reasons**, allowing a specific plant with desirable characterises to be **grown quickly, cheaply and in large quantities**. Cloning animals also has **commercial benefits**, but it much **slower** than cloning plants and more expensive.

Cloning in plants

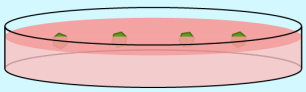
Tissue culture

Tissue culture, also known as micropropagation is the growth of **genetically identical** plants from **small pieces** of a parent plant.

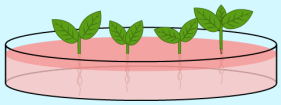
Method



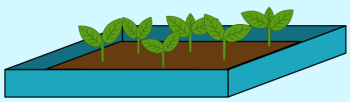
A **tissue sample** is scraped from the **parent plant.**



Small pieces of plants, known as **explants**, are placed in plates of sterile **agar jelly.**



Grow hormones that stimulate root and stem growth are added. The explants quickly turn into plantlets.



The **plantlets** rapidly grow into plantlets that are transferred into **potting trays**

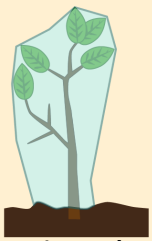
Cutting

Cutting is a simple way to clone **an adult plant, like a tree**. It involves taking a cutting, such as a **branch** from a tree, and planting it in **damp compost**.

Method

Take a **cutting** of a plant and remove lower leaves

Plant in **damp** compost with **root growth stimulating hormones**



Keep moist and warm for several weeks

A new plant that is a **clone** of the original plant grows

Cloning

Cloning in animals

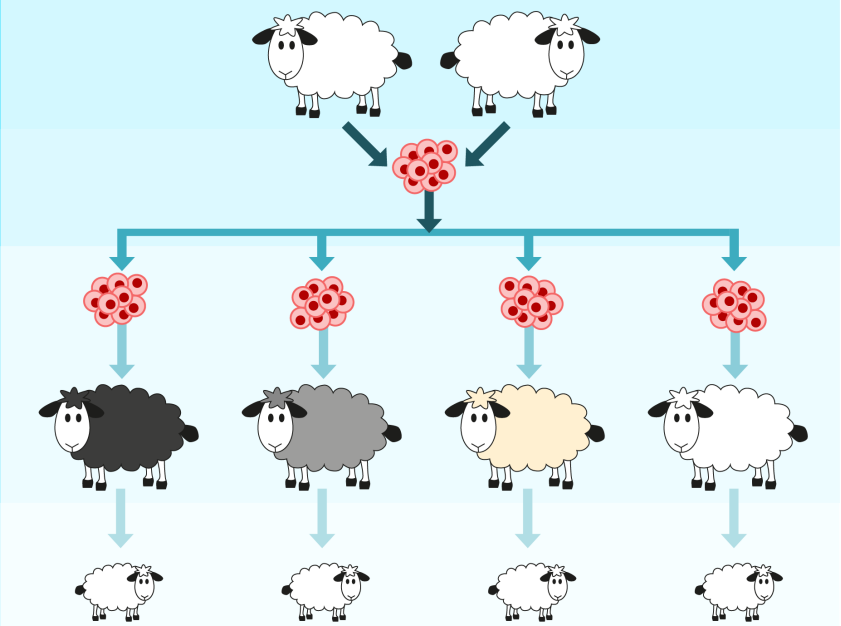
Embryo cloning

Embryo cloning is the **splitting** of an **embryo** to form **several identical embryos**. Embryo cloning is used in **scientific research and agriculture.**

Method

1. Parent sheep with **desired characteristics** are chosen.
2. The egg is **fertilised** with the sperm forming an embryo.
3. The embryo is **divided** to form many embryos.

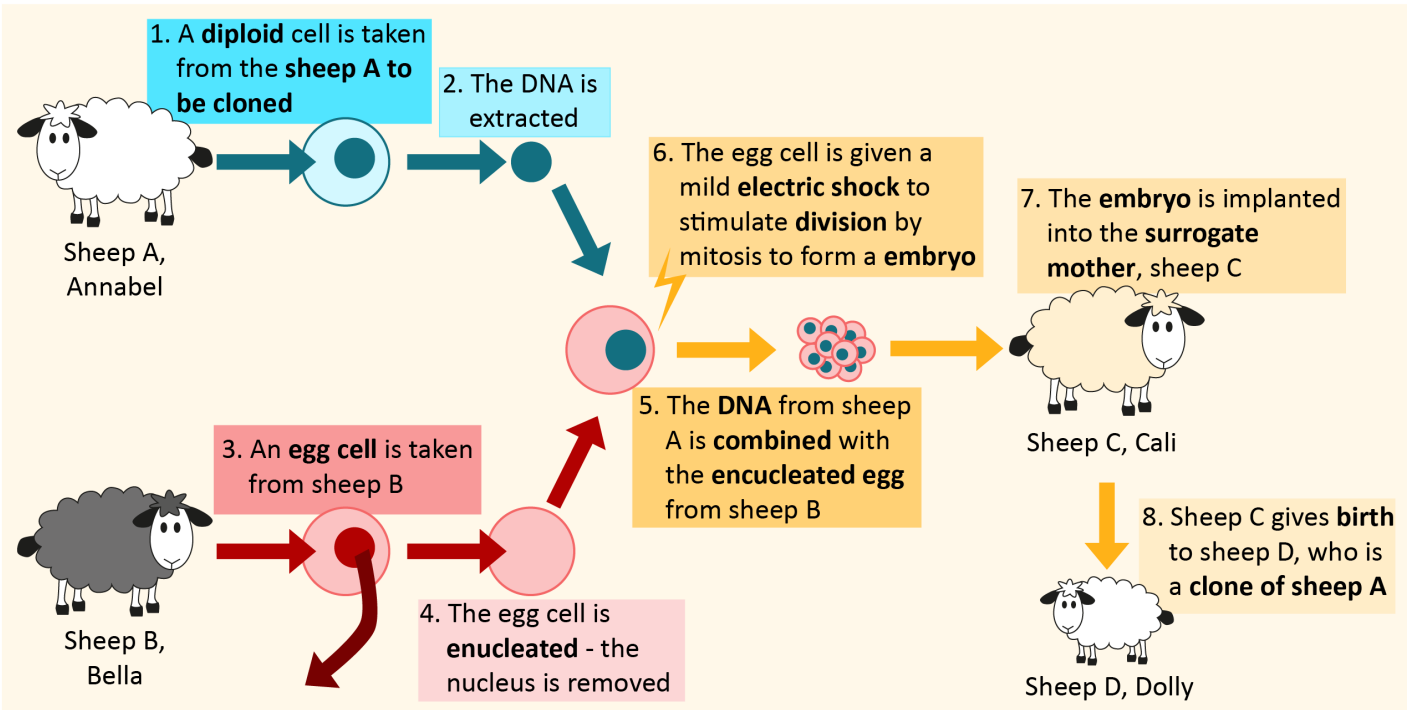
   These embryos are then **implanted** into **surrogate** mothers
4. The offspring are all **identical clones** from the same biological parents



Adult cell cloning

Adult cell cloning is the cloning of an **adult animal** by extracting the **nucleus** of one of its **diploid** cells and placing it in a donated **enucleated** egg cell. It was first done in sheep in 1996. The resulting clone was called Dolly, and she lived for seven years.

Method



Cloning

Benefits and risks of cloning

Risks

- Cloning leads to shorter lived animals and physical disabilities.
- Many people are worried about the use of cloning on humans; however, the purpose of this in real life is unclear – but it makes good plots in sci-fi films.
- Cloning also reduces the gene pool. Species with small gene pools are more likely to be completely wiped out by a disease.

Benefits

- Produces many offspring with desirable characteristic.
- The study of clones and cloned embryos could advance medicine.
- It can be used to help endangered species or even bring back extinct species.

Ethical questions

In some parts of the world, there are companies that offer to clone pets. However, it raises many ethical concerns, such as:

Should we put animals through physical pain to reduce our feeling of loss?

Why should we clone a pet, when many more need adopting?

Cloned animals live shorter lives and are often physically deformed, why should we do this to an animal?

Worked exam questions

(c) Some children have kidney disease. Kidney disease cannot be cured.
In the future, scientists could make a healthy clone of a child with kidney disease.
One kidney could then be transplanted from the cloned child into the child with kidney
disease. The cloned child would still live with only one remaining kidney.

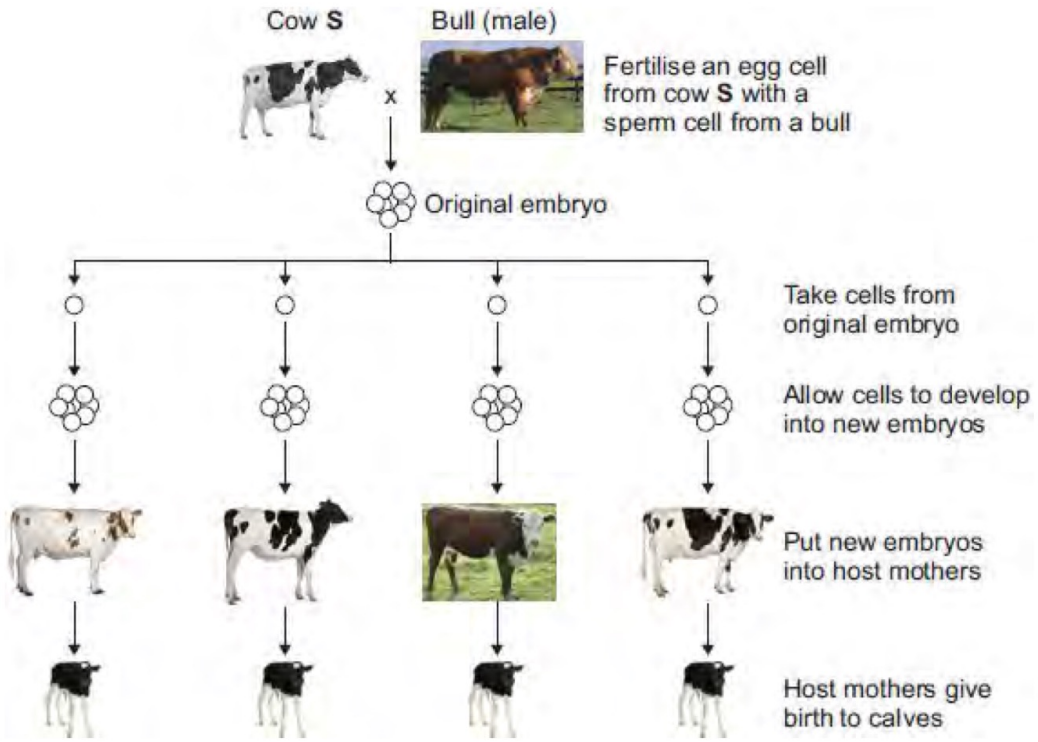
Suggest **two** reasons why people might disagree with cloning a child to get a kidney for transplanting.

1 It is immoral to bring a child into live just to save another

2 Cloned child would have to give up kidney

(2)

Cloning



(i) An egg cell from cow **S** is fertilised by a sperm cell from a bull. This is part of sexual reproduction.

What is the scientific name for sex cells such as egg cells and sperm cells?

Haploid

↑ hap sounds like half. Haploid cells only have 23 chromosnes

(1)

(ii) After fertilisation, cells are taken from the original embryo.

These cells develop into new embryos.

Which part of the host mother's body should each new embryo be put into?

womb

(1)

(b) (i) The calves born to all of the host mothers are genetically identical to each other.

Cloning

Draw a ring around the correct answer to complete the sentence.

The calves are genetically identical to each other because

they

- are formed from the same original embryo.
- have the same host mother.
- have the same two parents.

they do have the same Parents BUT this is not why they are identical

(1)

(ii) What term is used to describe the method of producing calves shown in the diagram in part (a)?

Tick (✓) **one** box.

- Adult cell cloning ☐
- Embryo transplantation ☑
- Genetic modification ☐

(iii) Why are the calves born to the host mothers **not** genetically identical to cow **S**?

Calves will have some genes from the bull

(1)

(b) Describe the cloning technique that scientists used to produce the embryo that grew into Dolly.

The quality of written communication will be assessed in your answer to this question.

1. Removal of diploid cell from sheep.
2. Extraction of DNA from diploid cell
3. DNA is inserted in to enucleated egg cell.
4. Egg cell is shocked to start division
5. Embryo is implanted in to surrogate mother sheep.
6. Dolly, the clone is born.

[6]