B12 reproduction

Asexual reproduction

Only one parent is needed in **asexual reproduction**. There is no fusion of **gametes** so genetic material does not mix, which means that the offspring produced through this process are genetically identical **clones** to the parent.

Examples of organisms that use asexual reproduction include:

bacteria

production of **spores** by **fungi**

some plants, such as strawberries, use runners

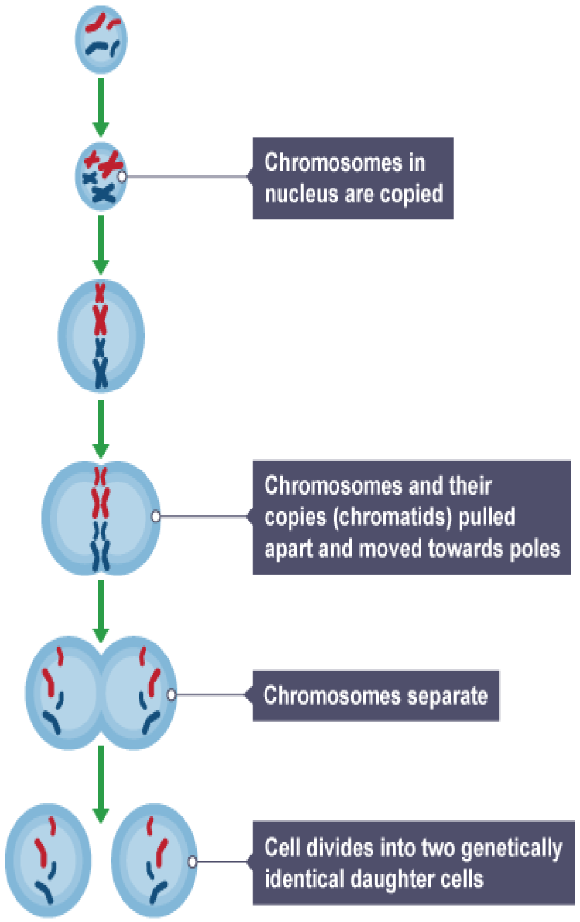
formation of **tubers** in potatoes and bulbs in daffodils

Sexual reproduction

Sexual reproduction

Two parents are needed in **sexual reproduction**. During this process the nuclei of the male and female **gametes** are fused in order to create a **zygote**. This process is known as fertilisation. The gametes contain half the number of chromosomes in each (haploid). When the male and female gametes combine they create the full complement of chromosomes (diploid) in order to create a human embryo.

Cell division: Mitosis.



Mitosis is part of the cell cycle, which involves:

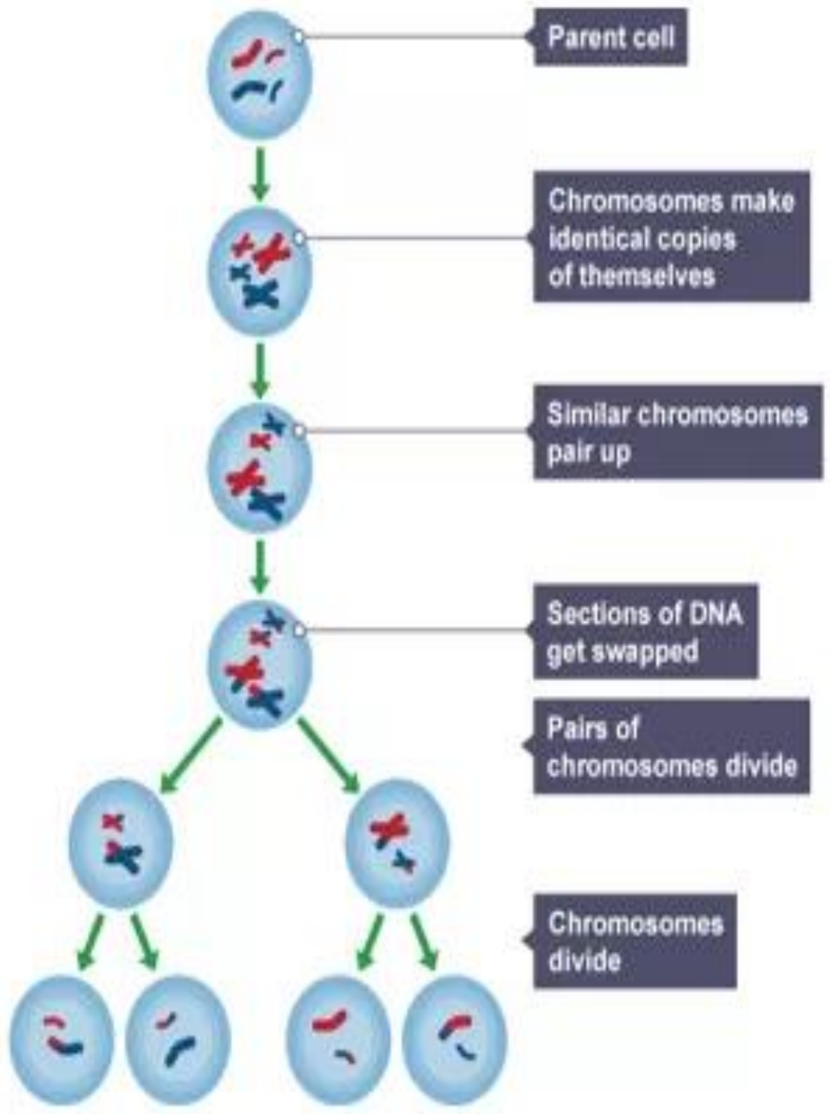
- cell growth, and the increase of the number of structures in the cell (mitochondria, ribosomes)
- genetic material is copied
- mitosis occurs leading to **chromosomes** separation and cell division

Mitosis is also used for:

- growth
- repair to damaged tissue
- replacement of worn-out cells

Meiosis:

- Sexual reproduction uses the process of **meiosis**, which creates gametes. The process of meiosis happens in the male and female reproductive organs. As a cell divides to form gametes:
- copies of the genetic information is made
- the cell divides twice to form four gametes, each with a single set of chromosomes (**haploid**)
- all gametes are genetically different from each other



Fertilisation:

- Fertilisation is the fusion of the **nucleus** of a male **gamete** with the nucleus of a female gamete. In humans, each gamete has half the number of the total 46 chromosomes that the body requires. Twenty three chromosomes within a gamete are referred to as a haploid. When the two gametes combine, they merge the two sets of chromosome to have 46, which are referred to as diploid.
- This produces a new cell called a zygote, which will mature into an embryo. The number of cells increase by mitosis, and as the embryo develops, the cells begin to differentiate (or specialise).

DNA, genes and chromosomes

- DNA
- The genetic material in the nucleus of a cell is composed of a chemical called DNA. DNA is a polymer, a large and complex molecule. It is made up of two strands forming a twisted ladder structure called a double helix. It carries the genetic code, which determines the characteristics of a living organism.

- Except for identical twins, each person's DNA is unique. This is why people can be identified using DNA fingerprinting. DNA can be cut up and separated, which can form a 'bar code' that is different from one person to the next.

- Chromosomes
- The cell's nucleus contains chromosomes. These are long threads of DNA, which are made up of many genes.

- Genes
- A gene is a small section of DNA in a chromosome. Each gene codes for a particular sequence of amino acids in order to make a specific protein. It is the unit of heredity, and may be copied and passed on to the next generation.

The human genome

- **The human genome**
- The **genome** of an organism is the entire genetic material of that organism. The whole human genome has been studied, and this has great importance for medicine.
- In order to exploit its secrets, it is vital that the human genome is fully understood.
- It enables us to:

- search for genes linked to different types of disease
- understand inherited disorders and their treatment
- trace human migration patterns from the past
- Scientists are searching for disease associated genes. One example was those that can contribute to breast cancer, which are known as *BRCA1* and *BRCA2*. Mutations in these genes account for approximately 10% of all inherited breast cancer cases detected.
- Scientists detected *BRCA1* and *BRCA2* genes by studying families where breast cancer was known to have been inherited between individuals. They were able to create a pedigree analysis, which is similar to a family tree diagram that showed the close relationship of those affected and unaffected within the family.
- The pedigree analysis illustrates the inheritance pattern of the disease to be determined. This enabled scientists to test DNA of the affected and unaffected individuals to identify differences. It is now possible to detect the presence of the genes by having a simple blood test.

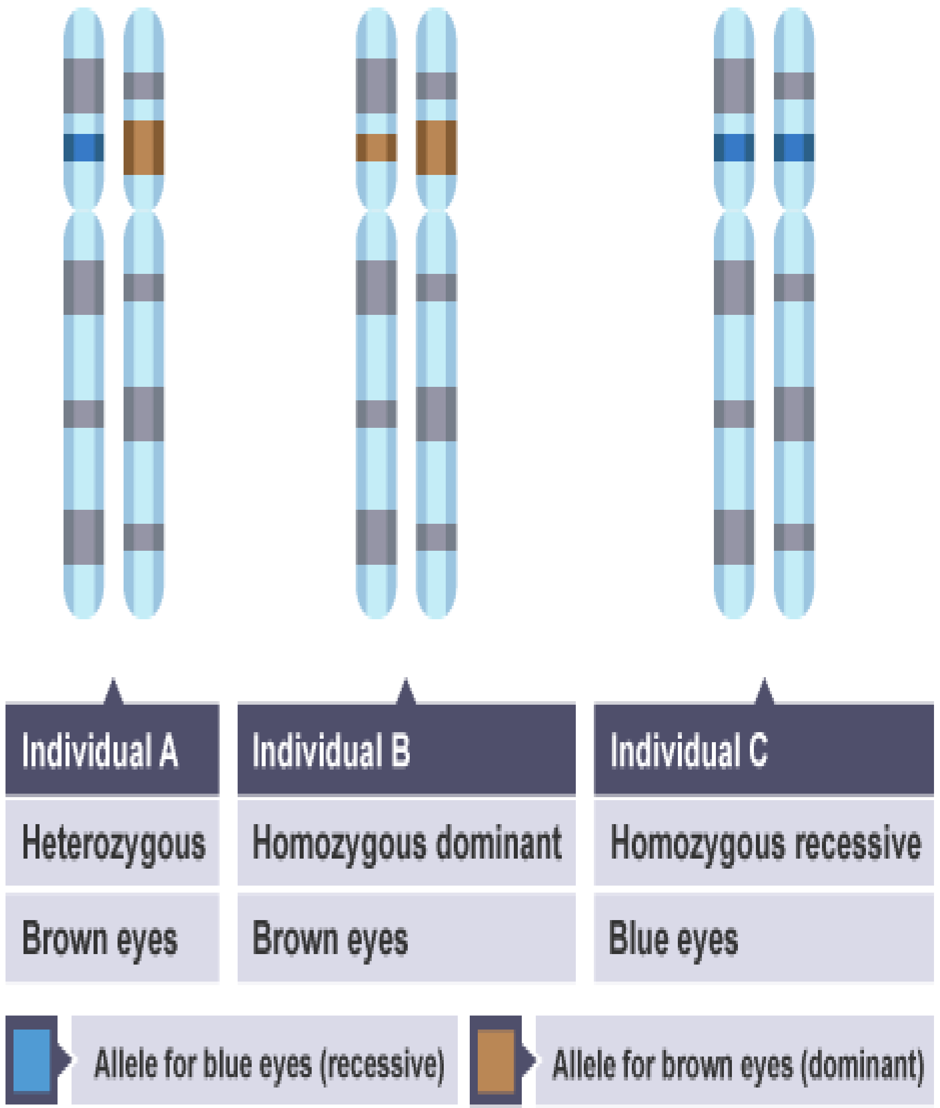
Ineritance:

- **Genetic key terms**
- A **gamete** is a sex cell. In humans, gametes are sperm and eggs (ovums). **DNA** is a large and complex polymer, which is made up of two strands forming a double helix. DNA determines the characteristics of a living organism. With the exception of identical twins, each person's DNA is unique.
- **Chromosomes** are contained inside the cell's **nucleus**. These are long threads of DNA, which are made up of many genes.
- A **gene** is a small section of DNA on a chromosome, that code for a particular sequence of amino acids, to make a specific protein. It is the unit of heredity, and may be copied and passed on to the next generation.
- Some characteristics are controlled by a single gene, such as fur in animals and red-green colour blindness in humans. Each gene might have different forms, and these are called alleles. The diagram shows the relationship between the cell, its nucleus, chromosomes in the nucleus, and genes.
-

•Chromosomes are found in the nucleus of a body cell in pairs. One chromosome is inherited from the mother and one is inherited from the father. The chromosome in each pair carries the same gene in the same location. These genes could be the same, or different versions.

•**Alleles** are **different versions** of the same gene. For example, the gene for eye colour has an allele for blue eye colour and an allele for brown eye colour. For any gene, a person may have the same two alleles, known as homozygous or two different ones, known as heterozygous.

•The **genotype** is the collection of alleles that determine characteristics and can be expressed as a **phenotype**.



		Mother	
		X	X
Father	X	XX	XX
	Y	XY	XY

Alleles may be either dominant or recessive:

- A **dominant allele** is always expressed, even if one copy is present. Dominant alleles are represented by a capital letter, for example, A. The allele for brown eyes is dominant. You only need **one copy** of this allele to have brown eyes. Two copies will still give you brown eyes.
- A **recessive allele** is only expressed if the individual has two copies and does not have the dominant allele of that gene. Recessive alleles are represented by a lower case letter, for example, a. The allele for blue eyes is recessive. You need **two copies** of this allele to have blue eyes.
- **Homozygous** alleles are both identical for the same characteristic, for example AA or aa.
- **Heterozygous** alleles are both different for the same characteristic, for example Aa.

Most characteristics are a result of multiple genes interacting, rather than a single gene.

Carrying out a genetic cross

Cystic fibrosis

Cystic fibrosis is an inherited disorder of cell membranes that mainly affects the lungs and digestive system. They can become clogged with lots of thick, sticky mucus as too much is produced. Over many years, the lungs become increasingly damaged and may eventually stop working properly. A number of treatments are available to help reduce the problems caused by the condition, but unfortunately average life expectancy is reduced for people who have it.

It is caused by a faulty **recessive allele** on chromosome 7. To be born with cystic fibrosis, a child has to inherit two copies of this faulty gene - one from each of their parents. Their parents will not usually have the condition themselves, because they will only carry one faulty gene and one that works normally.

		Mother	
		F	f
Father	F	FF	Ff
	f	Ff	ff

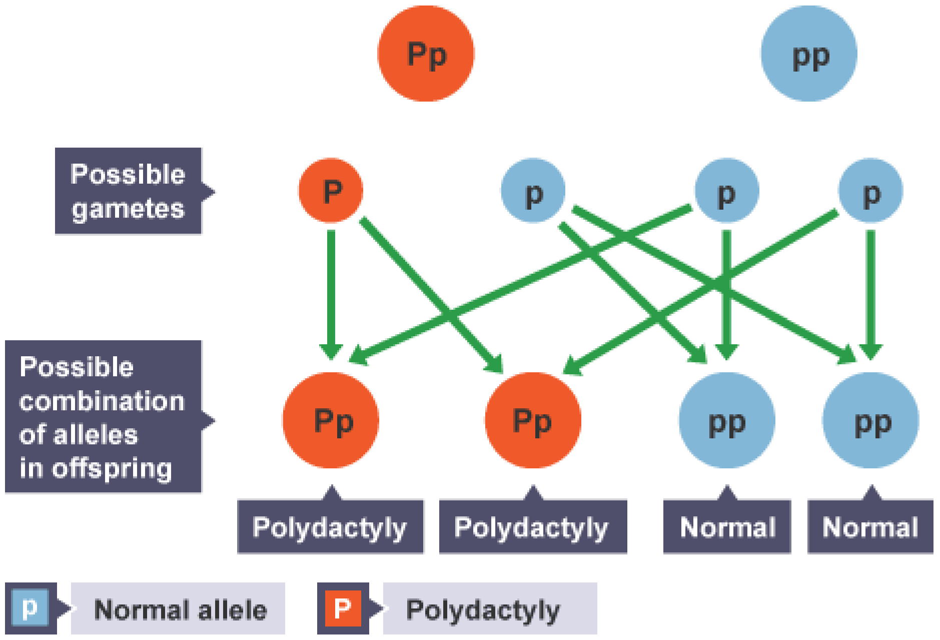
Polydactyly

Polydactyly is an inherited condition in which a person has extra fingers or toes. It is caused by a **dominant** allele of a gene. This means it can be passed on by just one allele from one parent if they have the disorder.

Someone who is homozygous (PP) or heterozygous (Pp) for the dominant allele will develop Polydactyly.

Offspring need to carry just one dominant allele from their parents to inherit the polydactyl condition.

The probability of the offspring having polydactyly is 50% (2 of the 4) and 50% not having it (normal). This can be expressed as a ratio, 2:2 which can be simplified to 1:1.



Genetic tests

Genetic testing involves analysis of a person's **DNA** to see if they carry alleles that cause genetic disorders. It can be done at any stage in a person's life.

•**Antenatal** testing is used to analyse an individual's DNA or chromosomes before they are born. This testing is offered to couples who may have an increased risk of producing a baby with an inherited disorder, but it can't detect all the risks of inherited disorders.

•Neonatal testing known as the new born blood spot test involves analysing a sample of blood that is taken from pricking a baby's heel. It detects genetic disorders in order to treat them early.

•**Pre-implantation genetic diagnosis** (PGD) is used on embryos before implantation. Fertility drugs stimulate the release of several eggs.The eggs are collected and fertilised in a Petri dish. This is known as in vitro fertilisation (IVF). Once the embryos have reached the eight-cell stage, one cell is removed.

•The cells are tested for the disorder causing alleles. Embryos that don't contain the disorder allele are implanted into the uterus.

Variation

Individuals in a population are usually similar to each other, but not identical. Some of the **variation** within a **species** is **genetic**, some is environmental - the conditions in which they have developed and some is a combination of both.

Genetic causes of variation

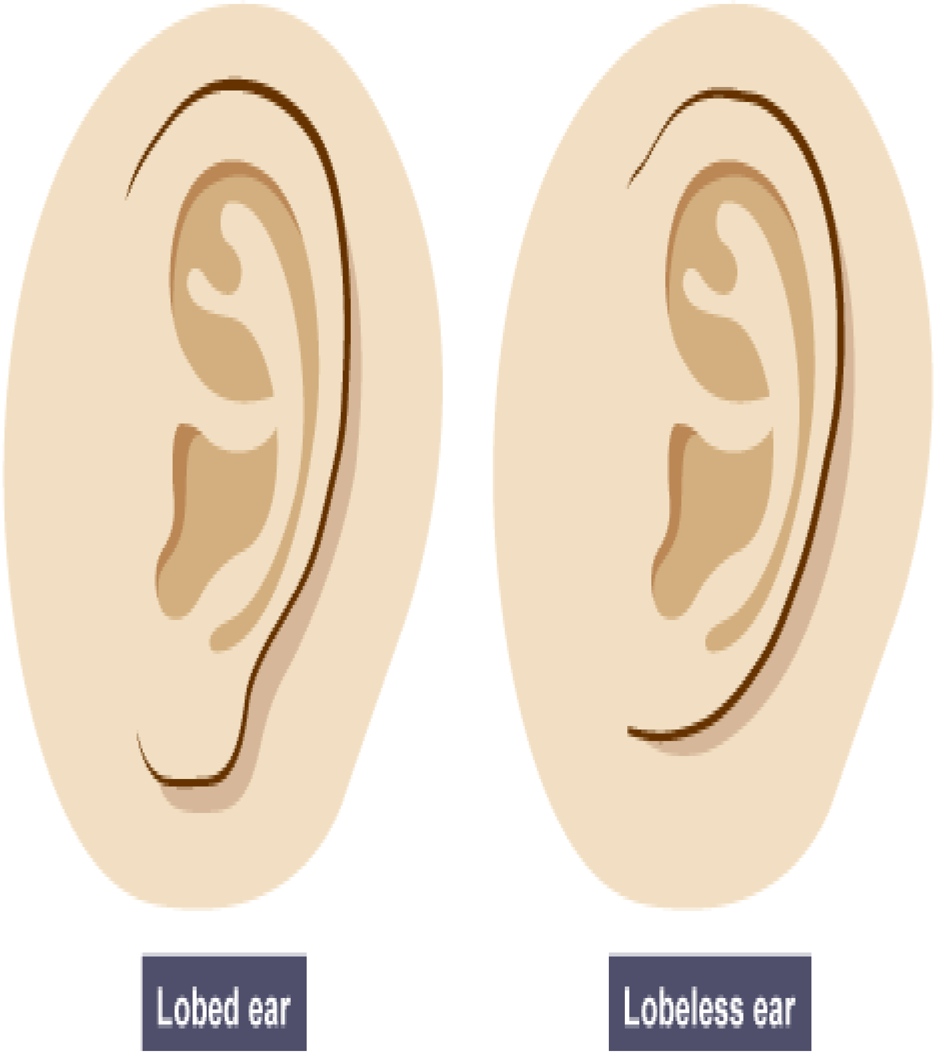
Children generally look a little like their mother and their father, but are not identical to either. They inherit their features from each parent's DNA.

Every sperm and egg cell contains half of the genetic information needed for an individual. Each sex cell is known as **haploid**, which has half the normal number of **chromosomes**. When the chromosomes fuse during **fertilisation**, a new cell is formed, which is known as a **zygote**. It has all the genetic information needed for an individual, which is known as **diploid**and has the full number of chromosomes.

Examples of genetic variation in humans include blood group, skin colour and natural eye colour.

Whether you have lobed or lobeless ears is due to genetic causes.

Some causes are environmental.



Mutation:

Variation within genes leads to different **genotypes**, and this can be seen by a different **phenotype**. Genetic and environmental variation combine together to produce these different phenotypes. All variants arise from **mutations** and most have no effect on the phenotype.

A **mutation** is a change in a **gene** or **chromosome**. Mutations arise spontaneously and happen continually. A mutation rarely creates a new phenotype, but if the phenotype is suited to a particular environment, it can lead to rapid change in a species. For example, if a mutation leads to a change, such as feather colouring in birds, this new change may allow those individuals to reproduce more frequently, due to them being more attractive and seen as a more desirable mate. This would result in this phenotype being passed on more successfully than the birds of the same species without the new phenotype.

Natural selection

Natural selection is a process where organisms that are better adapted to an environment will survive and have more offspring. This means their genes are passed on to the future generations. This process is fundamental to the process of **evolution**.

Charles Darwin was a famous English naturalist, who during his life came up with a theory of evolution. He is associated with the term 'survival of the fittest' which describes how natural selection works, by selecting the best examples of an organism to survive. For example, individuals that are best adapted to their environments are more likely to survive and therefore reproduce.

Selective breeding

Selective breeding or artificial selection is when humans breed plants and animals for particular genetic characteristics. Humans have bred food crops from wild plants and domesticated animals for thousands of years.

Main steps involved

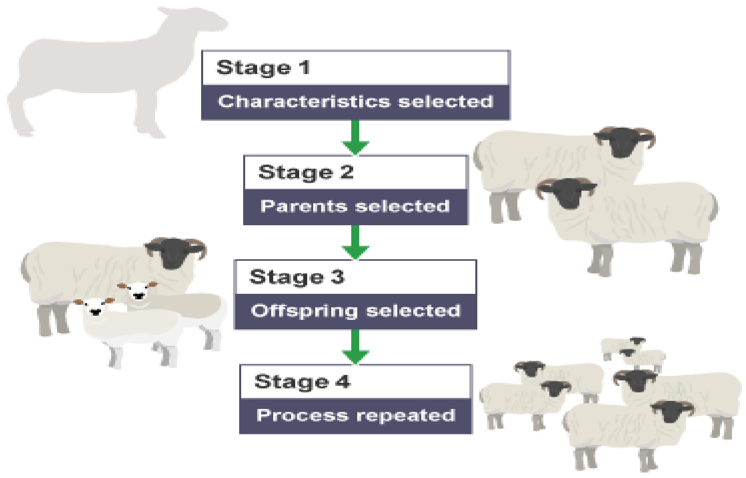
Selective breeding takes place over many generations. These are the main steps for both plants and animals involve:

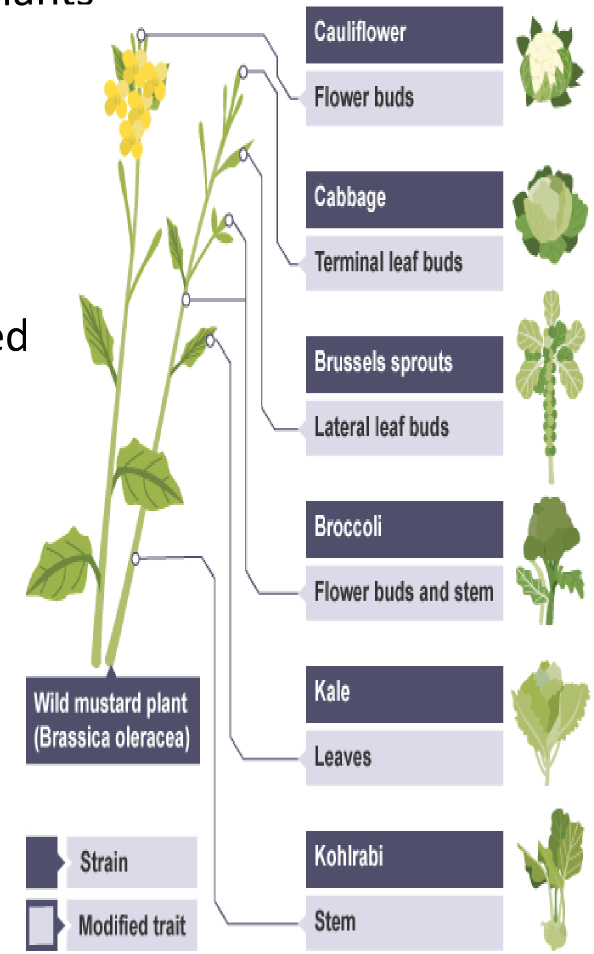
Decide which characteristics are important enough to select.

Choose parents that show these characteristics from a mixed population. They are bred together.

Choose the best offspring with the desired characteristics to produce the next generation.

Repeat the process continuously over many generations, until all offspring show the desired characteristics.





Benefits and risks of selective breeding

Because of **selective breeding**, future generations of selectively bred plants and animals will all share very similar genes which will reduce variation. Genes and their different **alleles** within a population are known as its gene pool. Inbreeding can lead to a reduced gene pool, making it more difficult to produce new varieties in the future. This also makes organisms prone to certain diseases or inherited defects.

Benefits of selective breeding include:

•new varieties may be economically important, by producing more or better quality food

•animals can be selected that cannot cause harm, for example cattle without horns

Risks of selective breeding include:

•reduced genetic variation can lead to attack by specific insects or disease, which could be extremely destructive

•rare disease genes can be unknowingly selected as part of a positive trait, leading to problems with specific organisms, eg a high percentage of Dalmatian dogs are deaf

•can create physical problems in specific organisms, eg large dogs can have faulty hips due to not being formed correctly

Genetic engineering

Genetic engineering is also called **genetic modification** or GM. It involves modifying the genome of an **organism** by introducing a **gene** from another organism to result in a desired characteristic.

Genetic engineering involves these steps:

selection of the desired characteristic

the gene responsible for the characteristic is 'cut out' of the **chromosome**

the gene is transferred and inserted into another organism

replication of the modified organism.

Plant crops have been genetically engineered to be disease resistant or to produce bigger fruits.

Current uses of genetic engineering

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, which results in cells receiving the glucose they need, and blood glucose levels stay normal.

Bacterial cells have been genetically modified to produce substances such as human insulin.

Genetically modified crops

Current genetically modified crops include those that are resistant to insect attack or are herbicide resistant, this produced increased yields. Herbicide resistant crops allow them to tolerate the herbicide, but the weeds are killed by it, thus overall less herbicide is needed.

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. In many countries golden rice is not being grown commercially over fears associated with genetically modified crops.

There are ethical issues involved in genetic modification, as well as 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 ethically wrong to create new life forms, or to move **genes**between different species.

Potential benefits and risks of genetic engineering

There are many benefits to using **genetic engineering**. It is used in agriculture to do things such as, improve the **yields** of important economic crops, and provide insect or pest resistance. It is also used in the medical field to create insulin, which can be used for treating **diabetes**. But, as with most new technology, it also carries potential risks.

Benefits of genetic engineering

•Genetic modification is a faster and more efficient way of getting the same results as selective breeding.

•Improve crop yields or crop quality, which is important in developing countries. This may help reduce hunger around the world.

•Introduce herbicide resistance, which results in less herbicides being used, as weeds are quickly and selectively killed.

•Insect and pest resistance can be developed and inserted into the plants. The plant produces toxins, which would discourage insects from eating the crop.

•Sterile insects could be created such as a mosquito. They would breed, which would lead to infertile offspring. This may help with spread of diseases, such as malaria, dengue fever and the Zika virus.

Risks of genetic engineering

•Transfer of the selected gene into other species. What benefits one plant may harm another.

•Some people believe it is not ethical to interfere with nature in this way. Also, GM crop seeds are often more expensive and so people in developing countries cannot afford them.

•GM crops could be harmful, for example toxins from the crops have been detected in some people’s blood.

•GM crops could cause allergic reactions in people.

•Pollen produced by the plants could be toxic and harm insects that transfer it between plants.

Principles of evolution by natural selection

The idea behind the theory of **evolution** through the process of natural selection is that all species of living things have evolved from simple life forms over a period of time. The Earth is about 4.5 billion years old and there is scientific evidence to suggest that life on Earth began more than three billion years ago.

This slideshow shows key events in evolution, from the first **bacteria** to humans.

Evidence of evolution - rock fossils

Fossils

A **fossil** is the preserved remains of a dead **organism** from millions of years ago. Fossils are found in rocks and can be formed from:

hard body parts, such as **bones and shells**, which do not decay easily or are replaced by minerals as they decay

parts of organisms that have not decayed because one or more of the conditions needed for decay are absent. For example, **dead animals and plants** can be preserved in **amber**, peat bogs, tar pits, or in ice

preserved traces of organisms, such as **footprints**, **burrows** and rootlet traces - these become covered by layers of **sediment**, which ever

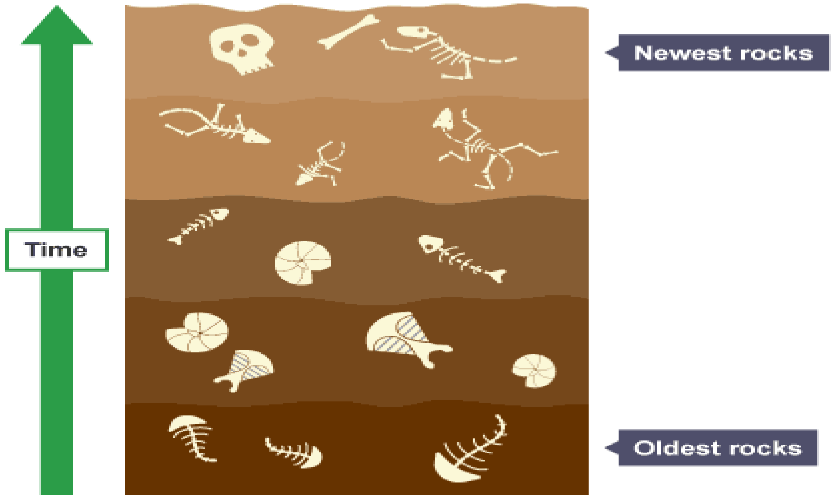
fossil record

Fossil remains have been found in rocks of all ages. Fossils of the simplest organisms are found in the oldest rocks, and fossils of more complex organisms in the newest rocks. This supports **Darwin's theory of evolution**, which states that simple life forms gradually evolved into more complex ones.

Evidence for early forms of life comes from fossils. By studying fossils, scientists can learn how much (or how little) organisms have changed as life developed on Earth.

There are gaps in the fossil record because many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were may have been destroyed by geological activity. This is why scientists cannot be certain about how life began.

Fossils provide a snap shot of the past and allow us to study how much or how little organisms have changed as life developed on Earth. Horse: page 192



Evidence for evolution - ice and peat fossils

Under certain conditions fossils might not have been created. Parts of organisms do not always decay because the conditions needed might be absent, and so they may be preserved in different ways. For example, **dead animals and plants** can be preserved in amber, peat bogs, tar pits, or in ice.

Amber is a substance that is formed from hardened tree sap or resin. This allows the whole organism to be seen clearly.

Britain's most famous peat bog body is known as the Lindow man. The acidic, oxygen-free conditions in the peat bog meant that the man's skin, hair and many of his internal organs were extremely well preserved, which is very unusual, as this does not occur with rock fossils. As more the of the Lindow man's DNA is preserved, it enables scientists to learn more about that era and how we may have evolved from the time that the man was alive.

Another well-known example of a body preserved in ice is Oetzi. He was a mummified ancient man found in 1991, near the Austrian Italian border. Detailed analysis of his body indicated that he was approximately 5,000-years-old. His body has been extensively examined, including his gut bacteria and pollen contained on some clothes.

Evidence for evolution - resistant bacteria

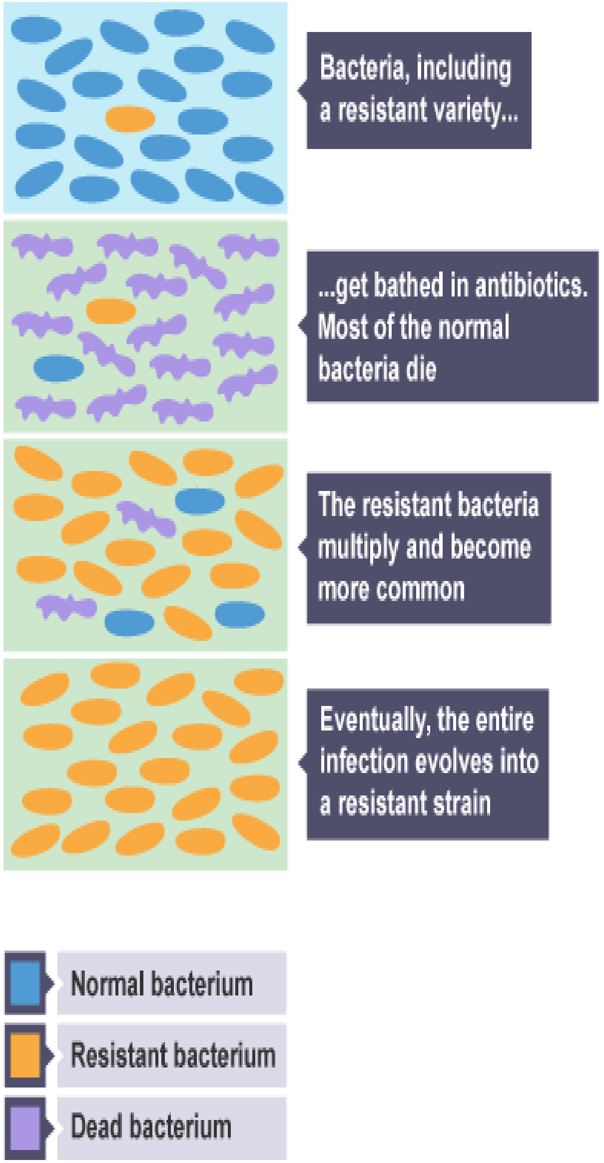
Antibiotic resistance

Bacteria can evolve quickly because they reproduce at a fast rate. Mutations of **bacteria** produce new strains. Some bacteria might become **resistant** to certain **antibiotics**, such as penicillin, and cannot be destroyed by the antibiotic. The evolution of the bacteria is an example of **natural selection**.

Development of resistance

The main steps in the development of resistance are:

1. random mutations occur in the genes of individual bacterial cells
2. some mutations protect the bacterial cell from the effects of the antibiotic
3. bacteria without the mutation die or cannot reproduce when the antibiotic is present
4. resistant bacteria can reproduce with less competition from normal bacterial strains



MRSA

The number of resistant strains has increased, partly due to the misuse of antibiotics. This has resulted in more infections that are difficult to control.

MRSA is methicillin-resistant *staphylococcus aureus*, and it is very dangerous because it is resistant to most antibiotics.

In order to reduce the rate of development of antibiotic resistant strains:

doctors should not prescribe antibiotics inappropriately, such as for the treatment of non-serious infections

patients should always complete the full course of antibiotics to ensure all bacteria are killed and none do not survive to mutate and form resistant strains

the agricultural use of antibiotics should be restricted

Penicillin was the first antibiotic to be produced on a mass scale in the 1940s. It is derived from Penicillium fungi, shown here growing on an agar plate.

Many new types of antibiotics were discovered during the 1950s and 1960s, but more recently, this has slowed greatly. Many scientists even stopped looking for new antibiotics, as they felt it was unnecessary.

Recent concerns of increasing resistance have created the need for new antibiotics, but they are costly and very slow to develop. Some scientists fear that we are fighting a losing battle against resistant bacteria, which may ultimately lead to people dying from simple infections, for example following operations.

Evidence for evolution

Extinction

Extinction occurs when there are no remaining individuals of a species alive.

Animals that have not adapted well to their environment are less likely to survive and reproduce than those that are well adapted. The animals that have not adapted to their environment may become extinct. Extinction has a role in evolution as some species disappear. Others survive and continue to evolve.

Several factors can cause a species to become extinct. They include:

- new diseases
- new **predators**
- new, more successful competitors
- changes to the environment over geological time, such as climate change
- a single catastrophic event, such as a massive volcanic eruption or a collision between an asteroid and the Earth

A species may also become extinct through speciation.

The fossil record shows that many species have become extinct since life on Earth began. Extinction is still happening and often, it is due to human activities. Humans compete with other living organisms for space, food and water - humans are very successful predators.

The dodo was a heavily-built flightless bird, roughly the size of a swan. It became extinct following the introduction of new predators by people.

Dodos lived on Mauritius, an island in the Indian Ocean. The island was uninhabited and the birds had no natural predators. When Mauritius was colonised by the Dutch in 1638, dodos were hunted for food. They were easy to catch and new competitors were brought onto the island, including pigs, cats and rats. They ate the dodos' eggs and their young. Within 80 years, the dodo was extinct.

Dinosaurs page 195 Classification pages 198-201