Inheritance

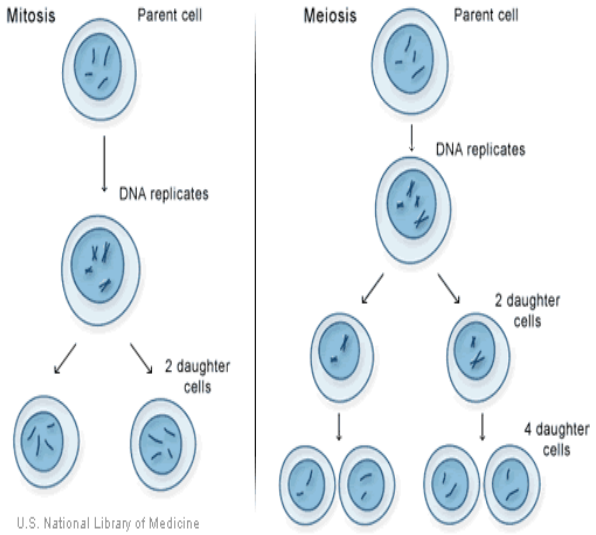
Sexual and Asexual Reproduction

1. Mitosis leads to identical cells being formed.
Asexual reproduction involves only one parent.
There is no mixing of genetic information or fusion of gametes.
Offspring are identical (clones).
2. Meiosis leads to non-identical cells being formed.
Gametes (sperm and egg in animals and pollen and egg in flowering plants) are formed using meiosis in the reproductive organs.
When a cell divides to form gametes:

- copies of the genetic information are made (mitosis with a slight mixing of DNA)
- the cell divides **twice** to form **four** gametes, each with a single set of chromosomes
- all gametes are genetically different from each other.

Sexual reproduction involves the joining (fusion) of male and female gametes to form a cell with a complete set of genetic information.
The new cell divides by mitosis. The number of cells increases. As the embryo develops cells differentiate and become specialised.
Genetic information is mixed which leads to variety in offspring.

Advantages of Sexual Reproduction	Advantages of Asexual reproduction
Produces variation in the offspring	Only one parent needed
If the environment changes variation gives a survival advantage by natural selection	More time and energy efficient as do not need to find a mate
Natural selection can be speeded up by humans in selective breeding to increase food production	Faster than sexual reproduction
Separate Biology only	Many identical offspring can be produced when conditions are right



- Malarial parasites reproduce asexually in the human host but sexually in the mosquito.
- Many fungi reproduce asexually by spores but also reproduce sexually to give variation.
- Many plants produce seeds sexually but also reproduce asexually by runners such as strawberries or bulb division such as daffodils.

Separate Biology only

Sex Determination

Ordinary human body cells contain 23 pairs of chromosomes.
22 pairs control characteristics only, but one pair carriers the genes that determine sex.
Females the sex chromosomes are XX.
Males the sex chromosomes are XY.

Inherited Disorders

Polydactyl (extra digits) is caused by a dominant allele. If a parent has Polydactyl (Pp) there is a 50% chance of the offspring inheriting it.
Cystic Fibrosis (disorder of the cell membrane where too much mucus is produced and the cilia can't move it away from the airways) is caused by a recessive allele. Both parents must be carriers (Nn) in order for there to be a 25% chance of a child inheriting the disorder.

Genetic Inheritance

Some characteristics are controlled by a single gene, such as fur colour in mice and red-green colour blindness in humans.
Each gene may have different forms called alleles
The alleles present are called the genotype and the characteristic that is expressed is called the phenotype.
A dominant allele is always expressed even if only one copy of the allele is present. And is written using a capital letter.
A recessive allele is only expressed if both alleles are present. And is written using a lower case letter.
If the two alleles present are the same the organism is homozygous for that trait, but if the alleles are different they are heterozygous.
Punnett squares are used to express the probable outcome of a genetic cross.

	R	r
r	Rr	rr
r	Rr	rr

Inheritance

DNA and the genome

The genetic material in the nucleus of a cell is composed of a chemical called DNA.

DNA is a polymer made up of two strands forming a double helix.

The DNA is contained in structures called chromosomes.

A gene is a small section of DNA on a chromosome. Each gene codes for a particular sequence of amino acids, to make a specific protein.

The genome of an organism is the entire genetic material of that organism.

The whole human genome has now been studied and this will help medicine in the future:

- search for genes linked to different types of disease
- understanding and treatment of inherited disorders
- use in tracing human migration patterns from the past.

Protein Synthesis

Separate Biology only

Proteins are synthesised on ribosomes according to a template.

Carrier molecules bring specific amino acids to add to the growing protein chain in the correct order.

When the protein chain is complete it folds up to form a unique shape.

This unique shape enables the proteins to do their job as enzymes, hormones or forming structures in the body such as collagen.

Mutations *Separate Biology only*

Mutations occur continuously. Most do not alter the protein or only alter it slightly so that its appearance or function is not changed.

A few mutations code for an altered protein with a different shape. An enzyme may no longer fit the substrate biding site or a structural protein may lose its strength.

Not all parts of DNA code for proteins. Non coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.

DNA Structure *Separate Biology only*

DNA is a polymer made from four different nucleotides.

Each nucleotide consists of a common sugar and phosphate group with one of four different bases attached to the sugar

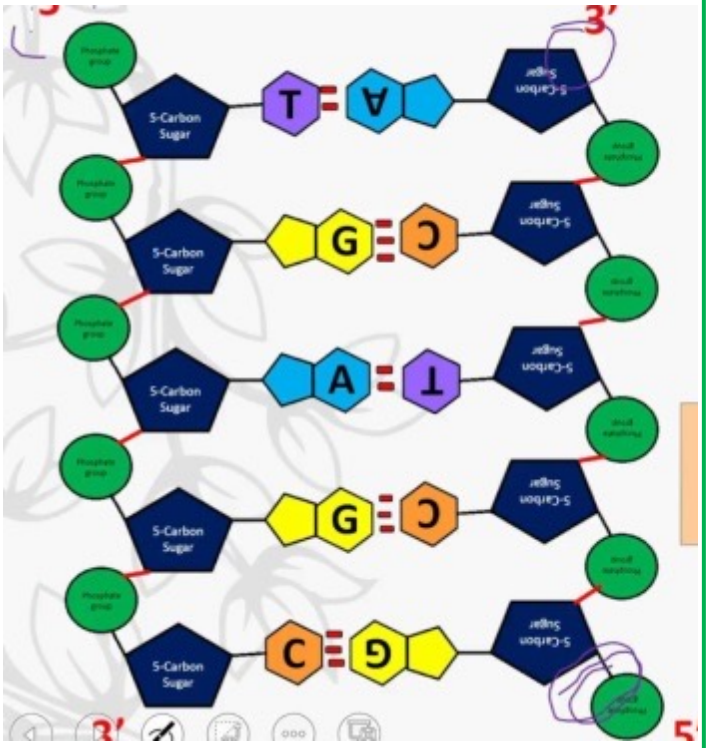
DNA contains four bases, A, C, G and T.

In the complementary strands a C is always linked to a G on the opposite strand and a T is always linked to an A.

A sequence of three bases is the code for a particular amino acid.

The order of bases controls the order of amino acids to produce a particular protein.

A change in DNA will produce a different sequence of bases and this results in a change in the protein synthesised by a gene.



Variation

Variation

Differences in the characteristics of individuals in a population is called variation and may be due to differences in:

- the genes they have inherited (genetic causes)
- the conditions in which they have developed (environmental causes)
- a combination of both.

There is usually extensive genetic variation within a population of a species.

All variations arise from mutations and most have no effect on the phenotype.

Evolution

This is a change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of a new species.

The **theory of evolution** by **natural selection** states that all species of living things evolved from simple life forms that first developed more than three billion years ago.

Natural Selection results in phenotypes (characteristics) that are best suited to their environment.

If two populations of one species become so different in phenotype that they can no longer breed to produce fertile offspring they have formed two new species.

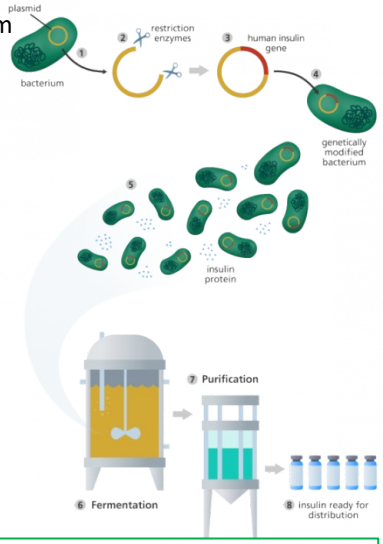
Genetic Engineering

Modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.

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

Bacterial cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes.

1. Genes from the chromosome of humans and other organisms can be 'cut out' and transferred to cells of other organisms.
2. Enzymes are used to isolate the required gene; this gene is inserted into a vector, usually a bacterial plasmid or a virus.
3. The vector is used to insert the gene into the required cells.
4. Genes are transferred to the cells of animals, plants or microbes at an early stage in their development so that they develop with desired characteristics.
5. Crops that have had their genes modified in this way are called genetically modified (GM) crops. GM crops include ones that are resistant to insect attack or to herbicides. GM crops generally show increased yields.



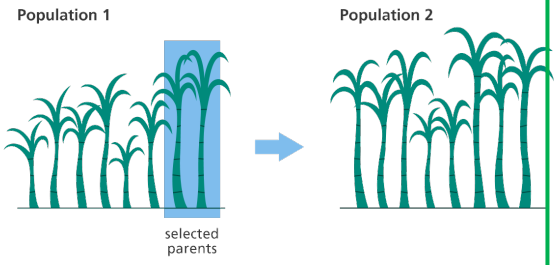
Concerns about GM crops include the effect on populations of wild flowers and insects. Some people feel the effects of eating GM crops on human health have not been fully explored.

Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders.

Selective Breeding

- Selective Breeding (artificial selection) is the process by which humans breed plants and animals for particular genetic characteristic.
- Humans have been doing this for thousands of years since they first bred food crops from wild plants and domesticated animals.

1. Parents with desired characteristics are chosen from a mixed population.
2. They breed together.
3. From the offspring those with the desired characteristics are bred together.
4. This continues over many generations until all the offspring show the desired characteristics:
    - diseases resistance in food crops
    - animals which produce more meat or milk
    - domestic dogs with a gentle nature
    - large or unusual flowers.



Selective Breeding can lead to "inbreeding" where some breeds are particularly prone to disease or inherited defects.

Variation *Separate Biology only*

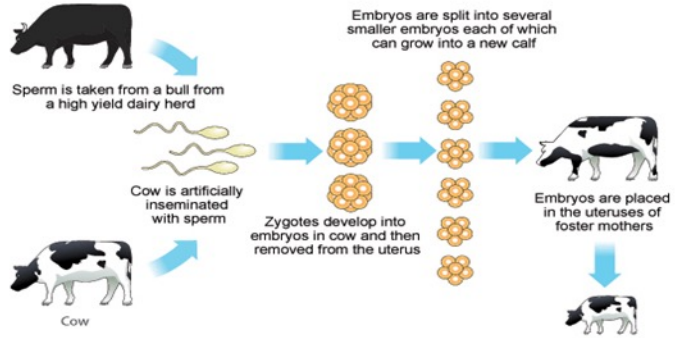
Cloning

Tissue culture:

Using small groups of cells from part of a plant to grow identical new plants. This is important for preserving rare plant species or commercially in nurseries.

Cuttings:

An older, but simple method used by gardeners to produce many identical new plants from a parent plant.

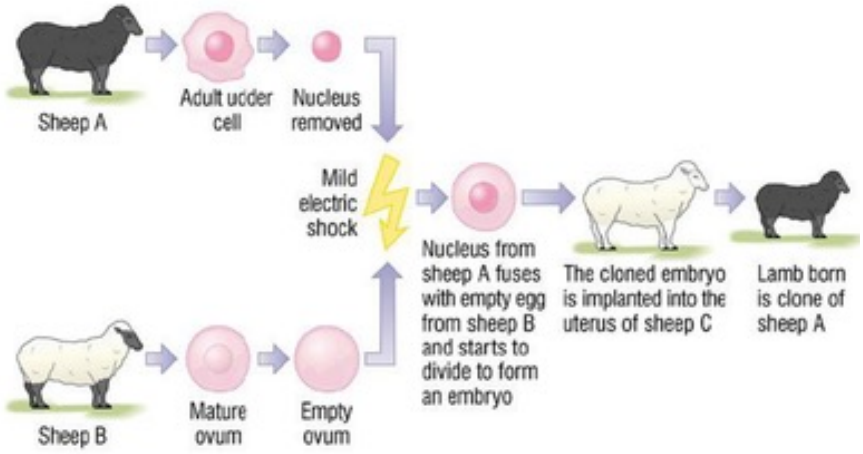


Embryo transplants:

Splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers.

Adult cell cloning:

The nucleus is removed from an unfertilised egg cell.
The nucleus from an adult body cell, such as skin cell, is inserted into the egg cell.
An electric shock stimulates the egg cell to divide to form an embryo.
These embryo cells contain the same genetic information as the adult skin cell.
When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.



Evolution

Evidence for Evolution

The theory for evolution by natural selection is now widely accepted.
Evidence for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in genes. There is further evidence in the fossil record and the knowledge of how antibiotic resistance evolves in bacteria.

Extinction

This occurs when there are no remaining individuals of a species still alive. It can be caused by:

- natural disaster
- disease
- habitat destroyed
- competition for food
- new predator.

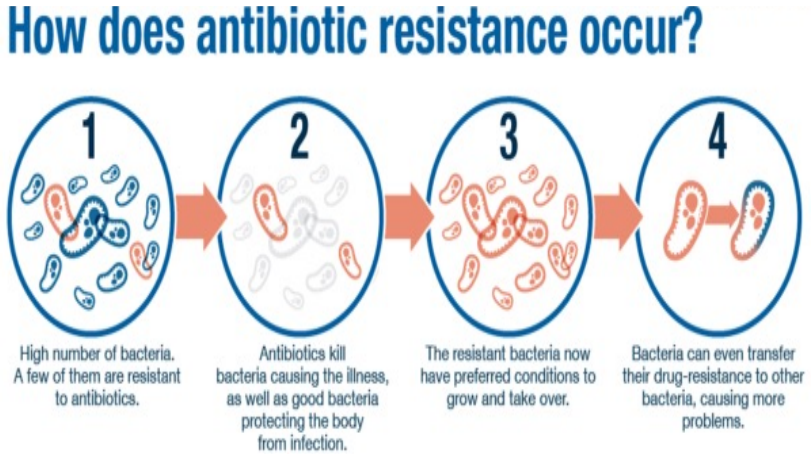
Fossils

Fossils are the 'remains' of organisms from millions of years ago, which are found in rocks.
Fossils may be formed:

- from parts of organisms that have not decayed because one or more of the conditions needed for decay are absent
- when parts of the organism are replaced by minerals as they decay
- as preserved traces of organisms, such as footprints, burrows and rootlet traces.

Many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were have been mainly destroyed by geological activity. This is why scientists cannot be certain as to how life began on Earth.
We can learn from fossils how much or how little different organisms have changed as life developed on Earth.

Resistant Bacteria



Bacteria can evolve rapidly because they reproduce at a fast rate.
Mutations of bacterial pathogens produce new strains. Some strains might be resistant to antibiotics, and so are not killed. They survive and reproduce, so the population of the resistant strain rises. The resistant strain will then spread because people are not immune to it and there is no effective treatment.
MRSA is resistant to antibiotics.
To reduce the rate of antibiotic resistant strains:

- doctors should not incorrectly or over prescribe antibiotics
- you should complete the course of antibiotics to ensure they are all killed
- the agricultural use of antibiotics should be restricted.

Evolution *Separate Biology only*

The Theory of Evolution

Charles Darwin, as a result of observations on a round the world expedition, backed by years of experimentation and discussion and linked to developing knowledge of geology and fossils, proposed the theory of evolution by natural selection.

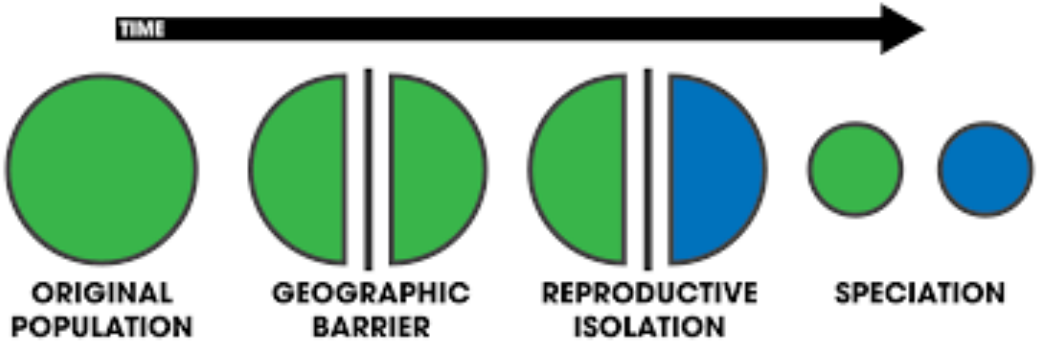
1. Individual organisms within a particular species show a wide range of variation for a characteristic.
2. Individuals with characteristics most suited to the environment are more likely to survive to breed successfully.
3. The characteristics that have enabled these individuals to survive are then passed on the next generation.

Darwin published his ideas in *On the Origin of Species* – the theory of evolution by natural selection was only gradually accepted because:

- the theory challenged the idea that God made all the animals and plants that live on Earth
- there was insufficient evidence at the time the theory was published to convince many scientists
- the mechanism of inheritance and variation was not known until 50 years after the theory was published.

Other theories – including **Jean-Baptiste Lamarck's** are based mainly on the idea that changes that occur in an organism during its lifetime can be inherited. We now know that in the vast majority of cases this type of inheritance cannot occur.

Speciation



- **Alfred Russell Wallace** independently proposed the theory of evolution by natural selection.
- He published joint writings with Darwin which prompted Darwin to publish 'On the Origin of Species' the following year.
- Wallace worked worldwide gathering evidence for evolutionary theory. He is best known for his work on warning colourations in animals and his theory of speciation.
- Wallace did much pioneering work on speciation but more evidence over time has led to our current understanding of the theory of speciation.

The understanding of genetics

In the mid 19th century, **Gregor Mendel** carried out breeding experiments on plants. One of his observations is determined by 'units' that are passed on to descendants unchanged.

His work was not accepted until after his death because:

- in the late 19th century the behaviour of chromosomes during cell division was observed
- in the early 20th century it was observed that chromosomes and Mendel's 'units' behaved in similar ways. This led to the idea that the 'units' now called genes were located on chromosomes
- in the mid 20th century the structure of DNA was determined and the mechanism of gene function worked out.

This scientific work by many scientists led to the gene theory being developed.

Classification

Classification of living organisms

Traditionally living things have been classified into groups, depending on their structure and characteristics, in a system developed by **Carl Linnaeus.**

Linnaeus classified living things into **kingdom, phylum, class, order, family, genus and species.**

Organisms are named by the binomial system of genus and species.

As evidence of internal structures became more developed due to improvements in microscopes, and the understanding of biochemical processes progressed, new models of classification were proposed.

Due to evidence available from chemical analysis there is now a 'three-domain system' developed by Carl Woese:

- archaea (primitive bacteria usually in extreme environments)
- bacteria (true bacteria)
- eukaryota (which includes protists, fungi, plants and animals).

Evolutionary trees are a method used by Scientists to show how organisms are related.