Classification

Scientists estimate that the numbers of species on Earth are from 10 million to 100 million. Classification is the organisation of living organisms into groups. This process is based on a number of accepted principles.

The concept of a species

The definition of a species is not easy, but members of a single species have certain things in common:

- **They are similar to one another but different from other species:** They have very similar genes and closely resemble each other physically and biochemically. They have similar patterns of development and occupy the same ecological niche.
- **They are capable of breeding:** This means when a species reproduces, any of the genes of the genes of its individuals can be combined and belong to the same gene pool.

Naming species- the binomial system

Over 200 years ago the Swedish botanist Linnaeus devised a common system of naming organisms. Its features are as follows:

- It's a universal system based on Greek or Latin names.
- The first name, the generic name, denotes the genus to which the organism belongs.
- The second name, the specific name, denotes the species where the organism belongs.

There are a number of rules applied to the use of the binomial system in scientific writing:

- The names are printed italics or if handwritten underlined.
- The first letter of the generic name is in upper case but the specific name in lower case.
- The specific name is not known and can be written as 'sp'.

Grouping species together- the principles of classification

The theory and practise of biological classification is called taxonomy.

There are two forms of biological classification:

- **Artificial classification:** Divides according to differences such as colour, size, number of legs etc. These are analogous characteristics where the have the same function but not the same evolutionary origins.
- **Natural classification:**

a) Based on evolutionary relationships between organisms + ancestors.
b) Classifies species into groups sharing features derives from ancestors.
c) Arranges into a hierarchy.

Organising the groups of species- taxonomy

Each group is called a taxon. The groups are positioned in a hierarchal order called taxonomic ranks. The largest group is called a kingdom within each kingdom the largest groups are known as phyla.

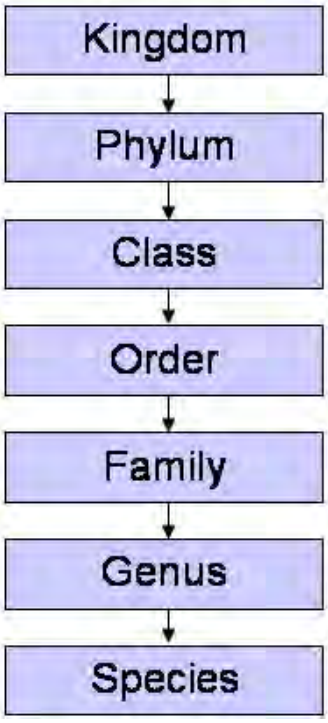
Phylogeny

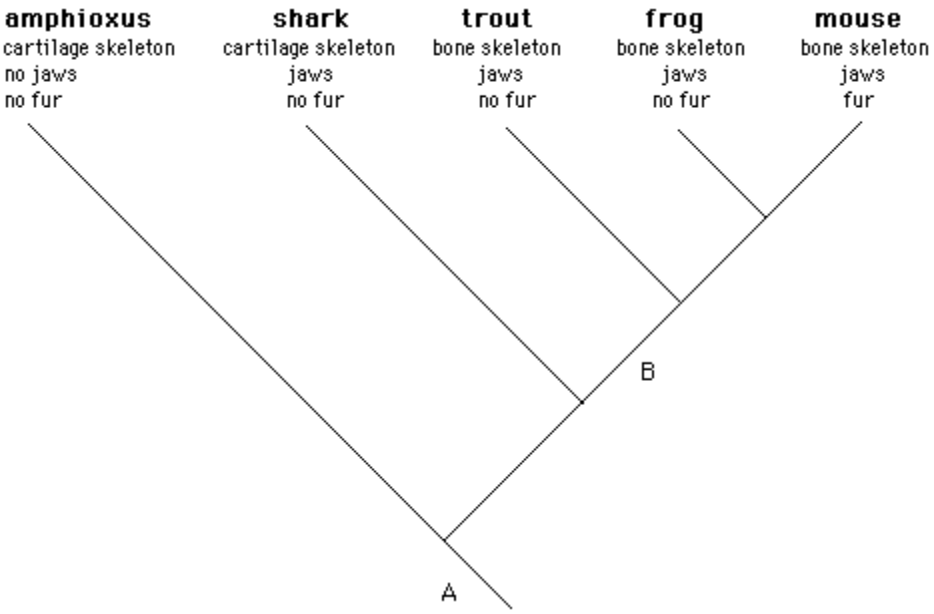
The phylogeny of an organism reflects the evolutionary branch that led up to it. The phylogenetic relationships of different species are represented by a tree like diagram called a phylogenetic tree.

The difficulties of defining species

- Species are not fixed forever and change and evolves over time.
- Within a species is a lot of variation.
- Many species are extinct.
- Some species rarely reproduce.
- Members of different groups of the same species may be isolated and never meet or interbreed.
- Groups of isolated organisms may be classified as a different species.
- Some species are sterile.

Linnaeus's System of Classification





Evidence for relationships between organisms

Comparison of DNA base sequences

When one species gives rise to another during evolution, the DNA of the new species will be similar to the species that gave rise to it.
Due to mutations, the sequences of nucleotide bases will change. Over time the new species will accumulate more and more differences in its DNA.

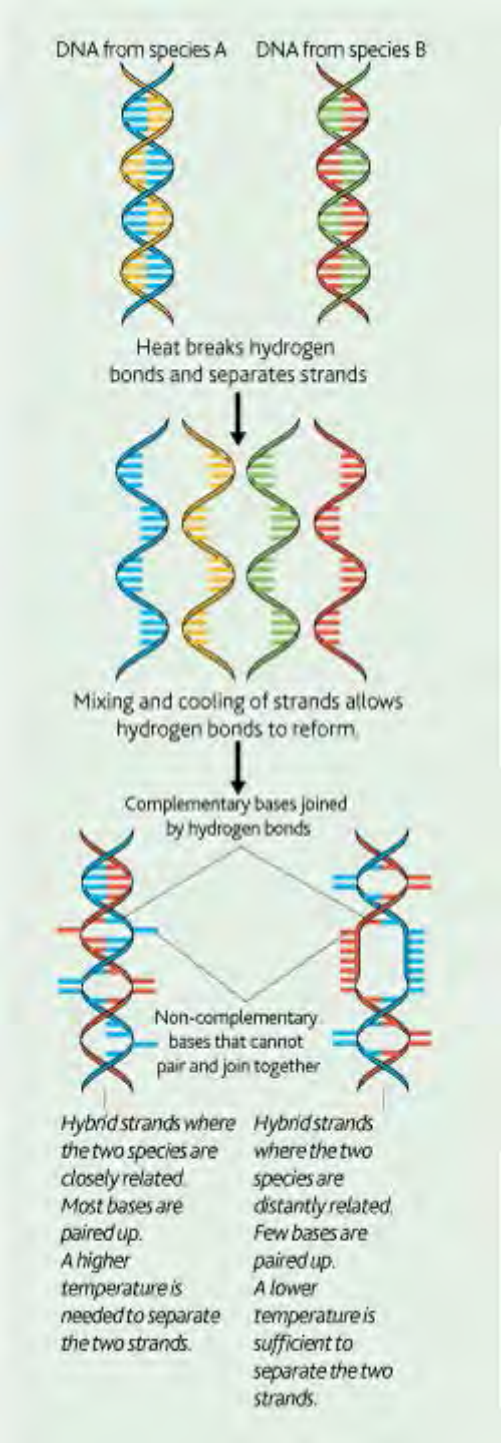
One way to determine similarities between the DNA of different organisms is to use DNA hybridisation.

DNA hybridisation

This depends upon a particular property of the DNA double helix. When DNA is heated, its double strand separates into two complementary strands. When cooled, the bases on each strand recombine with each other to reform the original double strand.

DNA hybridisation can be used to compare the DNA of the two species in the following way:

1) DNA from 2 species is extracted, purified and cut.
2) DNA from one species is labelled with a radioactive or fluorescent marker + mixed with the other DNA.
3) Mixture of DNA is heated to separate the strands.
4) It's cooled to allow the strands to combine.
5) Some double strands that reform will be made of one strand from each species (hybridisation). New strands are called hybrid strands (50% labelled).
6) Hybrid strands are separated out and temp is increased.
7) At each temp stage the degree that the 2 strands are linked is measured.
8) If the species are closely related they will share complementary bases.
9) More H bonds linking them in the hybrid strand.
10) The greater the amount of H bonds the stronger the hybrid strand.
11) The stronger the strand the higher the temp to separate it.
12) The higher the temp where it splits, the more related the 2 species are.



Use of DNA base sequencing in classifying plants

The recent classification of flowering plants has led to them being placed in one of two groups. The monocotyledons that have a single seed leaf (thin, narrow leaves) and the dicotyledons that have two seed leaves (broad leaves).

Scientists at The Royal Botanical Gardens, Kew devised a new classification of the families of flowering plants based on the DNA sequences of three genes found in all plants:
- They used 565 species that represented all the known families of flowering plants.
- For each plant, the DNA sequences of all 3 genes were determined.
- The sequences for each species were compared using computers.
- A phylogenetic tree was devised based upon the DNA sequences.

Comparison of amino acid sequences in proteins

The degree of similarity in the amino acid sequence of the same protein in 2 species will reflect how closely related they are.
Once the amino acid sequence for a chosen protein has been determines the 2 sequences are compared by counting similarities or differences in each sequence.

Immunological comparisons of proteins

The proteins of different species can also be compared using immunological techniques. The principle behind the method is that antibodies of one species will respond to antigens on proteins in the blood serum of another.

The process is carried out as follows:

- Serum albumin from species A is injected to B.
- Species B produces antibodies specific to antigen sites on the albumin from A.
- Serum is extracted from B that contains antibodies specific to antigens on albumin for A.
- Serum from B is mixed from serum from blood of a third species C.
- The antibodies respond to their corresponding antigens on the albumin of C.
- The response is the formation of a precipitate.
- The greater the number of similar antigens, the more precipitate formed and the closer they are related.

Courtship behaviour

Why is courtship behaviour necessary?

Courtship behaviour helps ensure that mating is successful by enabling individuals to:

- **Recognise members of their own species:** To ensure that mating only takes place between members of the same species.
- **Identify a mate that is capable of breeding:** because both partners need to be sexually mature, fertile and receptive to mating.
- **Form a pair bond:** that will lead to successful mating and rising of offspring.
- **Synchronise mating:** so that it takes place when there is the maximum probability of the sperm and egg meeting.

Courtship behaviour is used by males to determine whether a femal is at the receptive stage. If she responds with the appropriate behavioural response it continues and is likely to result in the production of offspring.

During courtship, animals use signals to communicate with mates and members of their own sex. Males carry out actions which acts as a stimulus to the female, who responds with a specific action of her own.

Adaptation and selection

Adaptation is when organisms adjust to suit the changing environment in which they live. Adaptation increases the long-term reproductive success of a species by helping members survive long enough to breed.

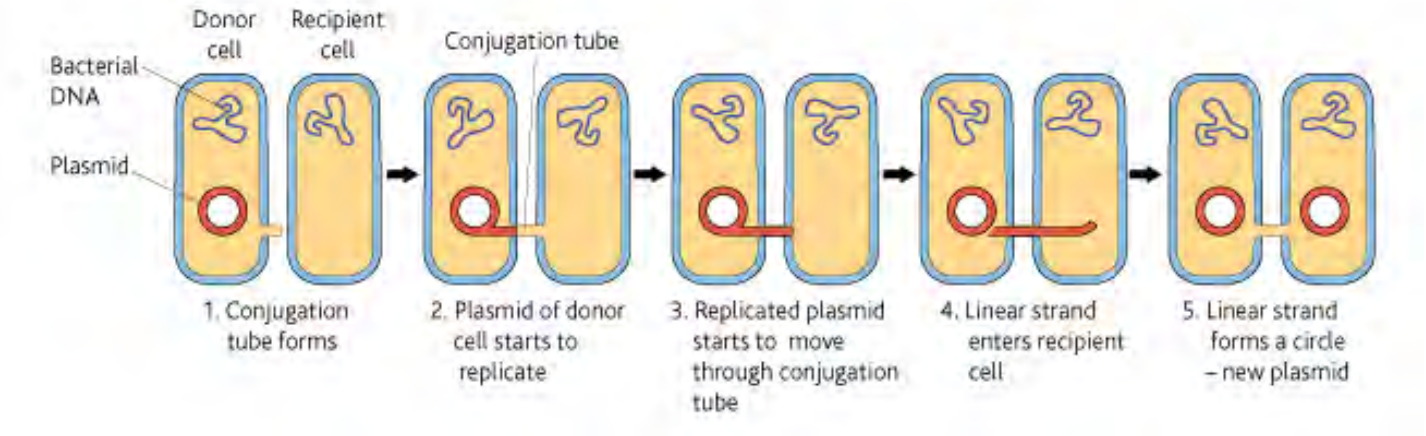
Diversity in organisms arises from changes to its DNA. These changes occur in two ways:
- Changing the quantity or structure of DNA of an organism (mutation).
- Recombining the existing DNA of two individuals (during sexual reproduction).

Mutations

Mutations are changes in DNA that result in different characteristics. They arise in many ways for example, some bases may be added, deleted or replaced during replication. Any differences in the base sequence of a DNA molecule results in a different amino acid sequence being coded for which will lead to a differet polypeptide. This means a different protein which can disrupt the metabolic pathway leading to production of other substances.

Conjugation

This occurs when one bacterial cell transfers DNA to another and takes place as follows:
- One cell produces a thin projection that meets another cell and forms a thin conjugation tube between the 2 cells.
- The donor cell replicates one of its small circular pieces of DNA (plasmid).
- The circular DNA os broken to make it linear before it passes along the tube to the recipient cell.
- Contact between the cells is brief leaving time for only a portion of the donor's DNA to be transferred.
- The recipient cell acquires new characteristics from the donor cell.



Antibiotics

How antibiotics work

One way they work is to prevent bacteria from making normal cell walls.
In bacterial cells, water constantly enters by osmosis. This entry of water would normally cause the cell to burst- osmotic lysis. It doesn't burst because of the cell wall that surrounds all of the bacterial cells.
The wall is made of tough material that isn't easily stretched. As water enters the contents expand and push against the cell wall.

Certain antibiotics kill bacteria by preventing them forming cell walls. They inhibit the synthesis and assembly of the important peptide cross-linkages in the bacterial cell walls. This weakens the walls making them unable to withstand pressure. As a result they are unable to prevent water entering and osmotic lysis occurs.

Antibiotic resistance

Shortly after discovery it became clear that the effectiveness of some antibiotics at killing bacteria was reduced. The populations of bacteria had developed resistance to antibiotics such as penicillin due to chance mutation.

In the case of resistance to penicillin the mutation resulted in certain bacteria being able to make a new protein which broke down the antibiotic penicillin.

The gene for penicillinase and hence antibiotic resistance is passes from one generation to the next by **vertical gene transmission.**

The allele for the resistance is carried on the circular loops of DNA called plasmids. These can be passed from cell to cell by conjugation. Resistance can find its way into other bacterial species by **horizontal gene transmission.**

Horizontal gene transmission can lead to certain bacteria accumulation DNA that gives them resistance to a range of antibiotics.

Antibiotic use and resistance

Antibiotic resistance and tuberculosis

One problem with the antibiotic treatments for TB is the long period for which the antibiotics must be taken.
After a number of months the patients feel better because of the majority of Mycobacterium that has been kills. They then feel tempted to stop taking the antibiotics. This is a problem as the few bacteria that remain are those most resistant to the antibiotic.

There is a selection pressure that leads to the development of strains of Mycobacterium that don't respond to the antibiotic. These strains interchange genes for resistance by conjugation.

To overcome this problem a 'cocktail' of three or four antibiotics is used to ensure at least one will be effective.

Antibiotic resistance and MRSA

Many people carry a bacterium belonging to the genus Staphylococcus in their throats. MRSA is the name given to any strain of this bacterium resistant to one or more antibiotics.
It is especially prevalent in hospitals and can present danger because:
- People in hospital are older, sicker and weaker making them more vulnerable.
- Many people live close together which is perfect for transmission.
-Many antibiotics are used in hospitals and so any mutant resistant strain has an advantage over non-mutant strains.

Implications of antibiotics use

Antibiotic resistance is on the increase for a number of reasons:
- Antibiotics are used to treat minor ailments whose symptoms are trivial/short lived.
- Antibiotics are sometimes used to treat viral diseases; they may help prevent the development of secondary bacterial infections.
- Patients do not always complete the course of antibiotics.
- Patients stockpile unused antibiotics.
- Doctors accept patients' demands for treatments.
- Antibiotics are used in the treatment of minor ailments in animals.
- They are used to prevent disease among intensively reared animals.