Biology Knowledge Organiser
B15 - Genetics and evolution

Classification the traditional way

People have always given living organisms names and attempted to group them together based on their similarities. The first system that has stuck around is the classification system described by Carl Linnaeus, in which he sorted organisms according to their **structure** (anatomy) and **characteristics**. He came up with a **hierarchical** system, where the larger groups contain all the smaller groups below them. It is called the Linnaean system, after him.

These groups, in order of size (based on how many organisms fit in each one) are called: **kingdom, phylum, class, order, family, genus** and **species**. Species are what you think of as individual types of organism – like tigers, oak trees or great white sharks. It is worth remembering that some organisms that are given one name in everyday language actually represent many species. For instance, there are many species of eagle and many species of shark.

When giving the scientific name of an organism, you give the genus and species. E.g. great white sharks are *Carcharodon carcharias*, humans are *Homo sapiens*. This is called the **binomial system** for naming species.

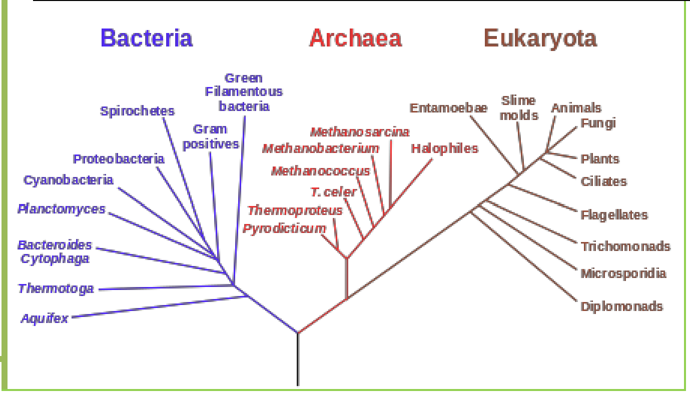
Classification the modern way

The Linnaean system dates back to the 18th century. Since then, knowledge and understanding of the internal structure of cells and biochemistry has developed significantly. Analysis of genetic material in cells has shown that the five kingdoms suggested by Linnaeus are not the best way to divide up life. A **three-domain system** is now used (although the Linnaean system is still very useful, and commonly used). The three-domain system was suggested by Carl Woese.

Woese's chemical analysis showed that there are three distinct groups of life, into which all organisms can fit without overlapping. These are called domains: the Archaea, Bacteria, and Eukaryota. One of the key things about this system is that is recognised that two huge groups of organisms (archaea and bacteria) are actually different. In the Linnaean system, they were bunched together in the 'bacteria' kingdom.

Since it is based on genetic analysis, the three-domain system links to the closeness of the relationship between organisms. We know all life on Earth is related (since we all use the same genetic code). That's why, when you draw an evolutionary tree (right), it starts with one 'trunk' – the first life on Earth (the **common ancestor** for us all). But, clearly, life has split into many different groups, as shown with the examples on the tree here.

Key Terms	Definitions
Classification	Sorting into groups. Traditional classification of organisms depends on their structure, but more modern methods involve analysing the biochemical similarities between organisms to classify them.
Kingdom	The largest group in the Linnaean system. In this model, there are five kingdoms (animals, plants, fungi, bacteria and protists).
Biochemistry	The study of chemicals in living organisms, such as DNA, proteins, carbohydrates and lipids.
Three-domain system	A modern model of classification, based on the genetic differences between organisms.
Archaea	Unicellular, like bacteria, but biochemically very different. These organisms often live in extreme environments, like very hot water around geysers. No-one realised that they were fundamentally different to bacteria before the chemical analysis was performed.
Bacteria	Also called 'true bacteria' – the prokaryotic organisms you think of as bacteria. (Check your knowledge on prokaryotic cells)
Eukaryota	All organisms with a nucleus, like us, plants, fungi and protists. All multicellular organisms fit into this domain (but it does include many unicellular organisms!).
Evolutionary tree	A method used to show how closely related organisms are. For living organisms, we can use genetic analysis; for extinct organisms, the fossil record suggest the relationships.



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Evidence for evolution

There is a vast haul of evidence to support Darwin's theory of evolution by natural selection. This evidence has built up over time: for example, Darwin didn't know about genes so found it hard to explain inheritance from parents in full. Obviously, we've got this knowledge now.

Thanks to all this evidence, Darwin's theory for evolution is now very widely accepted. Two key bodies of evidence for you to know are: the fossil record, and the evolution of resistant bacteria.

Fossils

Fossils are the remains of organisms. They are always old, typically millions of years old, and are found in rocks. They can form by:

1. The organism or parts of the organism don't **decay** because the conditions are not right for decay by microorganisms. For example, mammoths have been preserved in frozen mud.
2. Parts of the organism are replaced by **minerals** from the surrounding rocks as they decay. Most often, this results in soft tissues (e.g. muscle, skin) *decaying* normally, but the form of bones is preserved by the minerals in bones being swapped for minerals from the *rocks/sediments* that the dead organisms were buried under.
3. Preserved **traces** of organisms – so not their actual bodies, but traces like footprints, droppings, burrows and the traces of roots.

As most fossils are formed from bones, and many early forms of life had **soft bodies** (no bones), there are few traces of early forms of life. Any traces there were tend to have been destroyed by geological activity (movements of tectonic plates, volcanic activity and so on). This means the fossil record is **incomplete** and scientists cannot be totally sure about the origin of life on Earth.

The fossil record helps scientists fill in timelines and **evolutionary trees** to show how life has changed over time on Earth. Using evolutionary trees shows the closeness of relationships between different species.

Extinction

Extinctions of a species can happen for many reasons, and often extinction is due to more than one factor working together. Some key factors that may contribute to extinction of a species:

- Development of <u>new</u> species, so the old species doesn't exist any more
- <u>New</u> diseases affecting a species, which they aren't adapted to and can't survive
- <u>New</u> predators, to which a species cannot adapt fast enough to survive
- <u>Changes</u> to the environment, to which the species cannot adapt by natural selection, including <u>catastrophic</u> events (like the meteor strike that caused extinction of loads of species, e.g. dinosaurs)
- <u>New</u> competitors that are better adapted to the environment than the species.

Key Terms	Definitions
Fossil	The remains of organisms from millions of years ago, found in rocks. They are formed in different ways – see main text.
Strain	A variant of microorganism within a species – so they are not a different species to other variants, but have a key difference in their phenotype (e.g. being resistant to an antibiotic). New strains are produced by **mutations**.
Resistant strain	Describes a variant form of bacteria with resistance (NOT immunity) to a specific antibiotic.
MRSA	An example of a resistant strain of bacteria. It stands for methicillin resistant *Staphylococcus aureus*.
Extinction	When NO individuals of a species remain alive.
Evolutionary tree	A timeline that shows how closely related different species are to each other.

Resistant bacteria

The key factor that affects the **rate** of evolution is how fast an organism reproduces. Bacteria can reproduce as fast as doubling every 20 minutes, so they can evolve rapidly.

Thanks to a **mutation**, strains of bacteria that are **resistant** to an antibiotic can emerge. These are NOT killed by antibiotics used to try to kill them when the bacteria has infected someone. Consequently, they <u>survive</u> and <u>reproduce</u>, so the size of the resistant strain population increases generation to generation, while the non-resistant strain is wiped out. Furthermore, the resistant strain is likely to spread because if it infects other people and:

- They are not immune to it
- And there is no effective treatment.

Society benefits if we <u>reduce</u> the rate of development of antibiotic resistant strains of bacteria. Some methods to help save the day:

- Antibiotics should not be **prescribed** by doctors where they are not needed (especially for viral infections, since antibiotics don't work on viruses).
- Patients need to **finish the full course** of antibiotics they get prescribed, reducing the chance of any surviving and mutating to form resistant strains.
- **Restrict** the use of antibiotics in **agriculture**, as at present many animals receive antibiotics all the time to prevent infections and encourage growth.

We also badly need new antibiotics. However, it is slow and expensive to develop new antibiotic drugs, and at the moment we are not keeping up with the emergence of resistant strains of bacteria.