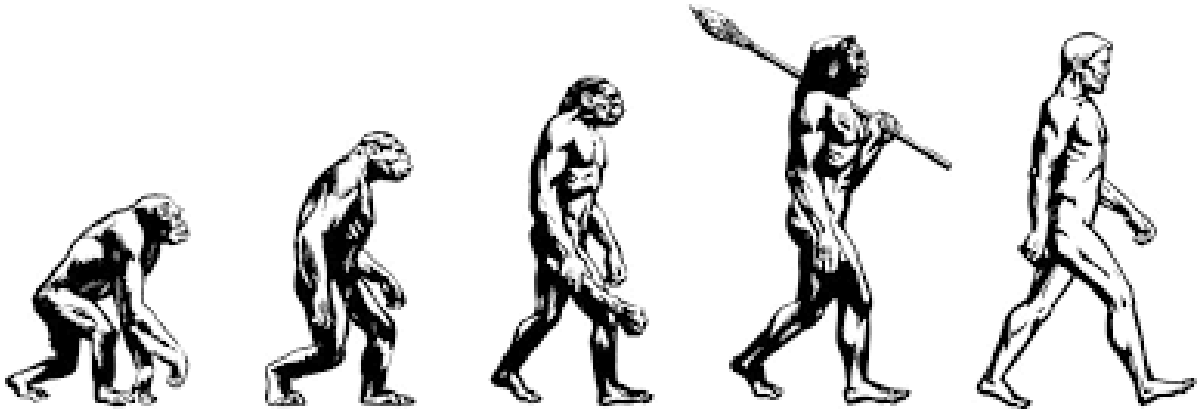
Adaptation & Evolution



Name _____

Class _____

Teacher _____

L1 What is a Species?

A species is a group of organisms capable of interbreeding and producing fertile offspring, and which does not normally breed with other groups.

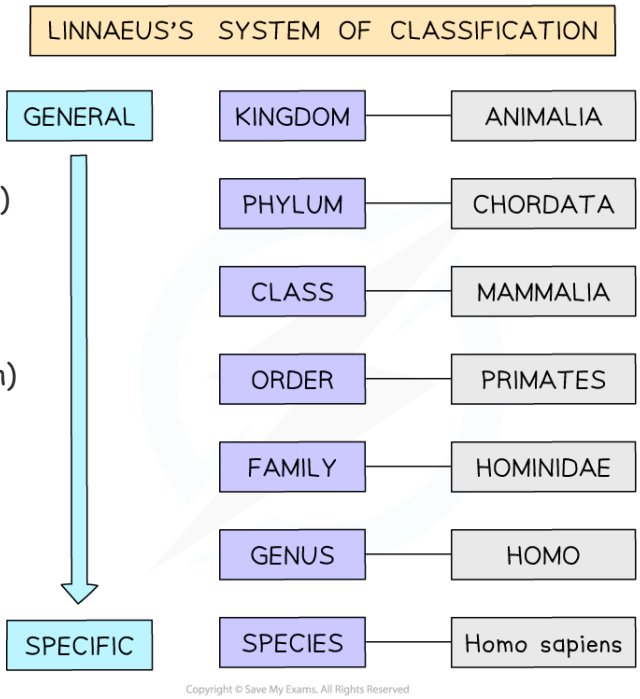
Dogs show significant variation, but can all interbreed and produce fertile offspring. Dogs are therefore one species.

Lions and tigers can breed but the offspring, like this ligress, cannot reproduce

Lions and tigers are able to interbreed producing a hybrid called a liger or tigon. However, ligers and tigons are infertile and cannot produce their own offspring. Lions and tigers are therefore different species. As long as a population has the opportunity to interbreed and exchange genes, they remain one species.

- There are millions of species of organisms on Earth
- A species is defined as a group of organisms that can **reproduce to produce fertile offspring**
- These species can be classified into groups by the **features that they share** eg. all mammals have bodies covered in hair, feed young from mammary glands and have external ears (pinnas)
- Traditionally living things have been classified into groups depending on their structure and characteristics in a system developed by Carl Linnaeus.
- Organisms were first classified by a Swedish naturalist called **Linnaeus** in a way that allows the subdivision of living organisms into smaller and more specialised groups
- The species in these groups have more and more features in common the more subdivided they get

- He named organisms in Latin using the **binomial system** where the scientific name of an organism is made up of two parts starting with the **genus** (always given a **capital letter**) and followed by the **species** (starting with a **lower case letter**)
- When typed binomial names are always in **italics** (which indicates they are Latin) e.g. *Homo sapiens*



- The sequence of classification is: **Kingdom**, **Phylum**, **Class**, **Order**, **Family**, **Genus**, **Species**

Independent practice

1. Define a Species
2. What is variation and how do dogs show it?
3. Why are dogs considered one species despite showing variation
4. Why are lions and tigers considered different species?
5. Roughly how many species of organisms are on Earth?
6. How can species be classified?
7. What is the name of the Swedish naturalist who developed the classification system?
8. What was his naming system called and what language was it in?
9. What rules are followed for naming using this system?
10. Can you think of a phrase to help you remember the order of the naming system?
11. Extended writing; Describe the Binomial naming system in detail. Use the following sentence starters.

The Linnean system classifies animals so…
The Linnean system classifies animals and…
The Linnean system classifies animals but …

L2 Competition

Water from the soil

Water is a reactant in photosynthesis and it is essential that plants have a regular supply of water for the process to occur. Some fully grown trees, like the oak tree, lose a staggering 150 litres of water per day, which is used to transport materials through the plant to the leaves. Some plants have roots that are shallow but extend a long way from the tree to maximise the uptake of water after rainfall. Others have roots that are deep to find stores of underground water.

Light

All plants and algae need light to *photosynthesise*. Plants compete for light by growing quickly to reach it and often shade other plants with their leaves. When an old tree in a forest dies and falls to the ground, there is a race to fill in the gap in the canopy. It doesn't look like a race to us because it happens slowly.

Minerals from the soil

Plants require minerals for healthy growth. These include *nitrates* and magnesium. Without sufficient minerals plants suffer *deficiency* diseases because they cannot grow healthily. Plants that grow in soils with few minerals, such as bogs, have evolved different ways of accessing nitrates. Some, like the Venus flytrap and pitcher plants, have evolved to be carnivorous and consume insects, enabling them to grow more successfully than their competitors on mineral poor soil.

Space

Plants also require space for healthy growth. This means their leaves are not shaded which maximises photosynthesis. Some gardeners have experimented by planting vegetables very close together. These result in much smaller vegetables being produced.
Competition can be *intraspecific*, for example competition between oak trees in a forest, or *interspecific* such as when another *species* of tree like birch or yew grew next to oak trees.
When a woodland tree dies, other younger trees compete to replace it. This competition ensures the growth of the healthiest individuals, and maintains vigour in the population.
Individuals within a species that cannot compete effectively are unlikely to reproduce, and may die. This is known as survival of the fittest and is a driver for *evolution*.
Whole species that are unable to effectively compete may become *extinct*.

Mates

Animals within a species also compete for mates. This is essential so they can pass on their *genes* to their offspring. Animals have evolved to have an innate or natural drive to reproduce, and this competition often results in fights. This is seen each year when animals like red deer group together at the start of the mating season. Large male deer fight with each other by locking antlers and pushing hard, which is called a rut. In deer, and many others species, these fights competing for mates can often result in serious injury or death, but benefits the population as only the strongest pass on their genes to the next generation.

Food

All animals require food which provides them with energy and raw materials to complete *life processes*, without which they may die. Because of these, competition for food can be fierce. There are many birds which eat insects in our gardens, and some have evolved to only eat certain types of insect to reduce competition from other *species*. Others like the blue tit and great tit compete with other members of their own species and as well as others for different insects. Because food is so vital, many animals will fight for it.

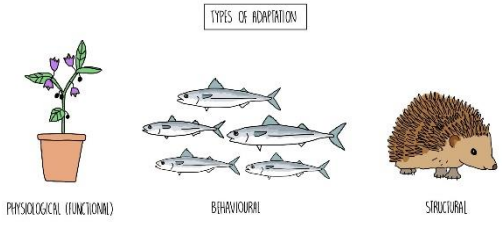
Territory

The territories of animals contain all of the resources and conditions they need to survive. These include *abiotic* factors such as light, temperature and water, and oxygen for aquatic animals. There are also *biotic* factors such as food and predators. Many animals, including the cats in back gardens, will fight for territory. An example of *intraspecific* competition over territory would be between lions on the grass plains of Africa whereas *interspecific* competition would occur when another *predator* like leopards lived close to the lions.

Living organisms display features (**adaptations**) which make them suited to living in a particular habitat and more likely to survive. These adaptations can be **behavioural**, **physiological** or **structural**.

- **Behavioural adaptations** are the way that an organism **acts** which increase its chances of survival. For example, fish often swim in groups called schools for protection and birds migrate south during the winter to find food.
- **Physiological/functional adaptations** are **processes** which occur **within the body** of an organism which increase its chances of survival. For example, sloths have a slow metabolism which means they can survive on food which contains a low number of calories and plants such as the deadly nightshade produce a poison which is a defence against being eaten by animals.
- **Structural adaptations** are **physical features** of an organism which increase its chances of survival. For example, polar bears are camouflaged against the snow and cacti have spines to prevent being eaten by animals.

Extremophiles are organisms which live in an **extreme environment**, such as high temperature, high pressure or high salt concentrations. For example, some **bacteria** live deep in the ocean on **hydrothermal vents**, where temperatures and pressures are very high.



Independent practice

1. what do plants compete for?
2. What do animals compete for?
3. What do plants use water for?
4. What do plants find in the soil?
5. How do plants compete for sunlight?
6. How does competition for mates display itself in the Deer population?
7. What is survival of the fittest?
8. How have birds evolved to eat insects?
9. What are Abiotic factors and how do they effect an organism's territory?
10. What are the three types of adaptations?
11. Give an example of each
12. Extended writing: explain how a camel is adapted to survive in its environment. Include structural, functional and behavioural adaptations.

L3 Natural Selection

Evolution is a change in the inherited characteristics of a population over time through the process of natural selection, which may result in the formation of new species. *Natural selection* is a process where organisms that are better adapted to an environment will survive and reproduce. This means that the advantageous genes of this variant organism are passed on to offspring. Over many generations, the process of natural selection leads to *evolution* occurring.
Charles Darwin was a famous English naturalist. During his life he came up with the theory of natural selection and how this drives *evolution* of new species.
Darwin is associated with the term 'survival of the fittest', which describes how natural selection works. Individual organisms in an environment are 'selected for'. This means that only the organisms that have the best characteristics for that particular environment will survive. If they survive then they are the 'fittest' for this environment, they reproduce and pass on the advantageous characteristics to their offspring.

Natural selection: peppered moths example

Light peppered moths camouflage themselves against light lichens on Birch trees.
Before the industrial revolution in Britain, in the early 1800s, most peppered moths were of the pale variety. This meant that they were *camouflaged* against the pale Birch trees that they rest on. Moths with a mutant black colouring were easily spotted and eaten by birds. This gave the white variety an advantage, and they were more likely to survive to reproduce.
During the last half of the 1800s, airborne pollution in industrial areas blackened the Birch tree bark with soot. This meant that the mutant black moths were now camouflaged, while the white variety became more vulnerable to predators. This gave the black variety an advantage, and they were more likely to survive and reproduce. The dark moths passed on the genes for black wing colour leading to offspring with the black wing colour. Over time, the black peppered moths became far more common in urban areas than the pale variety.
Note: that this change was not due to pollution making the moths darker. The dark variety had always existed, but was the best suited variant when the environment changed. It took many generations before the population of moths was mainly black in colour.

Giraffes

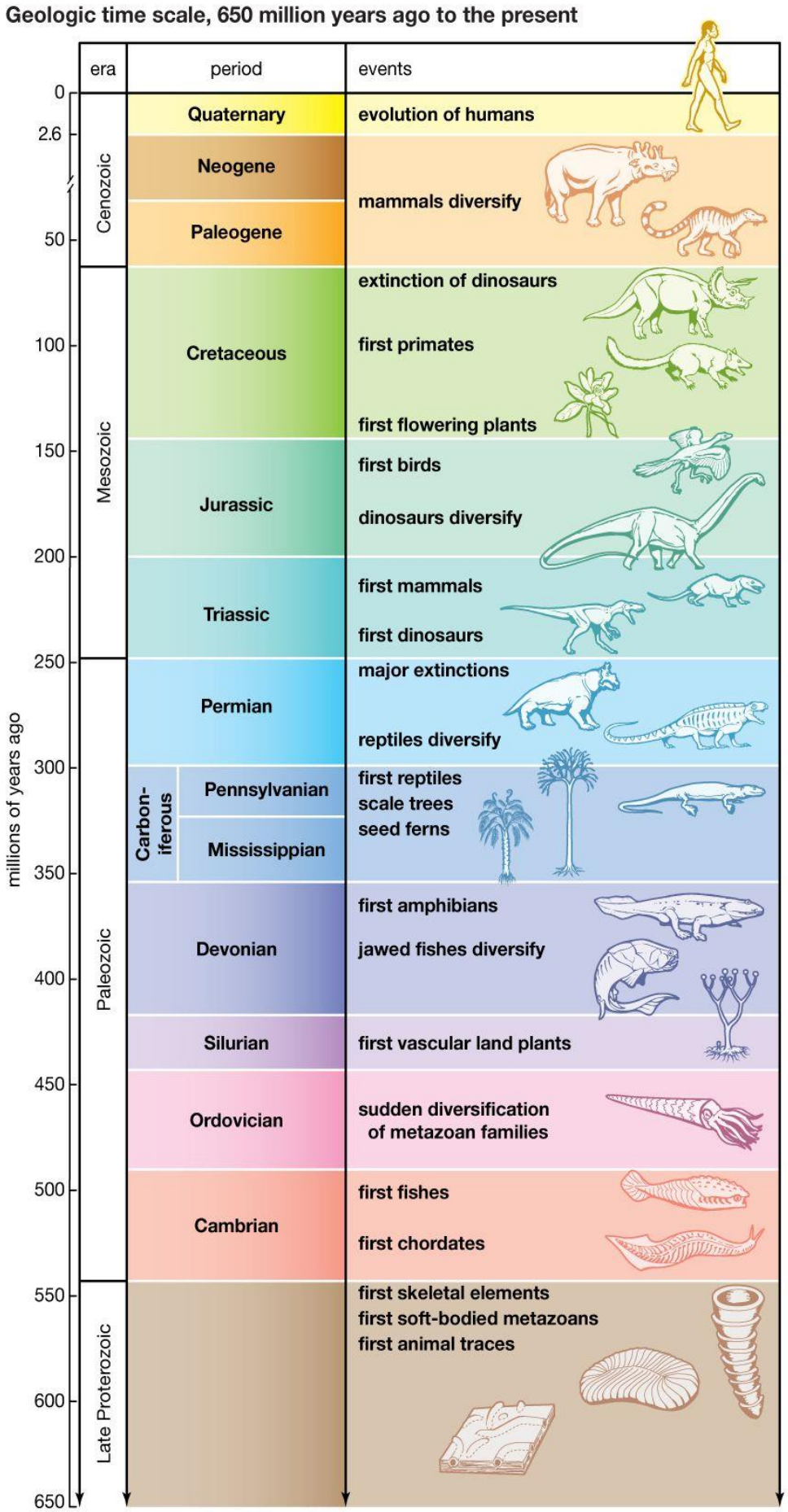
Let's now suppose that there is a mutation that results in a giraffe having a slightly longer neck. The longer necked giraffe will be able to reach higher up leaves on trees, which means that it is able to get plenty of food. This increases the chances of survival for the giraffe, which means that it is more likely to reproduce and pass on these longer necked genes onto future generations. This will result in there being a greater number of giraffes with longer necks in the population.

The giraffes with shorter necks in the population will now have characteristics that are less favourable. This is because the shorter necked giraffes will be unable to reach as high in trees, which may mean that they won't be able to get sufficient food for survival, which could result in the shorter necked giraffes dying. As the shorter necked giraffes die, they won't reproduce and therefore won't pass their genes onto future generations. This will result in giraffes with shorter necks becoming less prolific in the population.

Independent practice

1. Define Evolution
2. When an organism is better adapted to an environment, what is it able to do?
3. What will the offspring of this organism inherit?
4. What happens over many generations of natural selection?
5. Explain survival of the fittest.
6. What do both variations of the moth look like?
7. Extended writing; Explain the story of the peppered moth and how natural selection occurred over time.
8. How did the giraffe end up with a long neck?
9. Describe how animals in a population may change over time
10. Describe how a single preferable trait may be pass to whole population over time
11. Explain how this may change an entire population over time

L4 Evolution



The idea behind the theory of *evolution* throug h the process of natural selection is that all *species* of living things have evolved from simple life forms over a period. 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.

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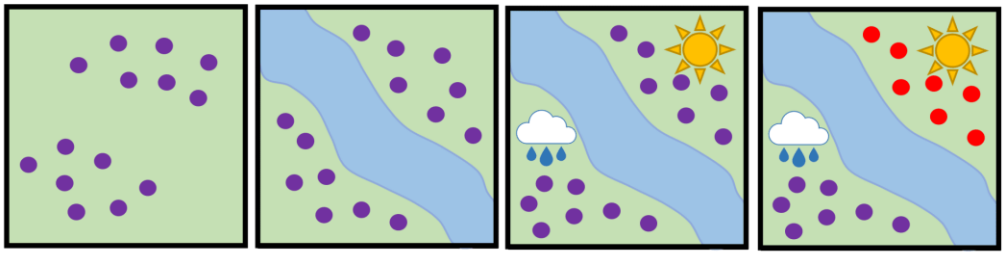
Natural selection can lead to speciation over time. This means that each population will begin to evolve different adaptations to suit their environment and will eventually be so physically and genetically different that they can't breed and produce live, fertile offspring. This means that the two populations are now two separate species, and speciation has occurred.

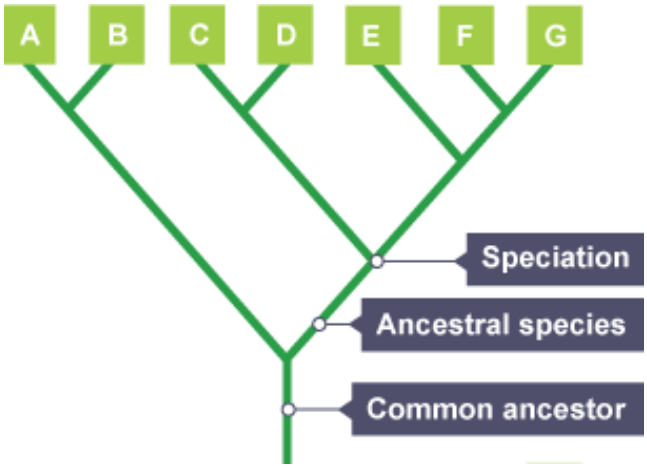
Speciation is the formation of new species and can happen as a result of isolation and natural selection.

1. Populations of species are separated due to a physical barrier such as a river or mountain range.
2. Environmental conditions differ between the two areas.
3. Certain individuals in each population will be more adapted to the new environment.
4. Natural selection will cause individuals with the advantageous traits to survive, reproduce and pass on the advantageous genes.
5. This causes the advantageous traits to become more common in certain populations.
6. Over time, the isolated populations will become so different that they will not be able to interbreed to produce fertile offspring and so will be two separate species.



Alfred Russel Wallace was one of the first people who studied speciation. He provided the foundation knowledge for future investigations which led to out current understanding of the concept. He worked along side Darwin and they published their findings in 1858 (a year before Darwin published 'On the Origin of Species').

Evolutionary trees are used to represent the relationships between organisms. Branches show places where *speciation* has occurred, and a new species has evolved.



In this evolutionary tree, species A and B share a recent common ancestor. Species A is therefore most similar to species B.
Species F and G also share a recent, common ancestor, however this common ancestor is different to the common ancestor of A and B. The common ancestor of F and G shared a common ancestor with species E. All seven species share a common ancestor at the bottom of the tree, probably from the distant past.
The information is collected from a variety of sources such as fossil records and DNA sequences. The more varied the *evidence* collected, the more likely the scientists are to be correct in their decisions about how closely related different organisms are.

<u>Independent practice</u>

1. What is the idea behind the theory of evolution?
2. How old is the Earth?
3. How long ago did life begin on Earth?
4. What does Speciation mean?
5. How does Speciation occur?
6. How does natural selection cause speciation?
7. How does isolation cause speciation?
8. Who first studied speciation and when was his work first published?
9. On the evolutionary tree, which species is G related to closest and which is furthest?
10. Extended writing; Explain how to read and evolutionary tree. Give detail about each feature of the diagram.

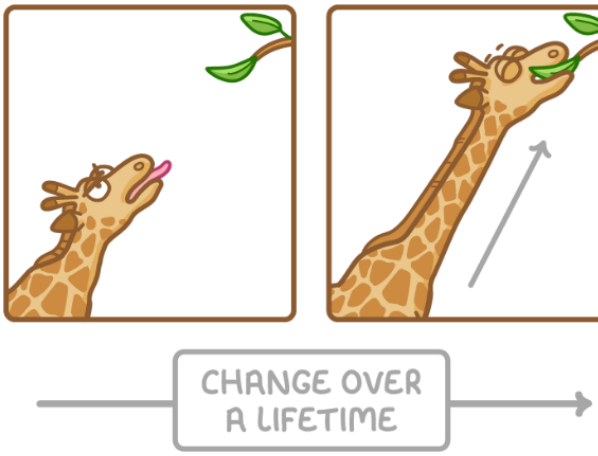
L5 Darwin

Scientists' understanding of evolution has changed over time, from early theories like Lamarck's to the currently accepted theory of natural selection proposed by Darwin and Wallace.

Jean-Baptiste Lamarck's early theory of evolution suggested that organisms could acquire new traits during their lifetime, and that these traits could be passed to their offspring.

According to Lamarck's theory, giraffes have long necks because:

1. Giraffes started with short necks adapted to lower vegetation.
2. They stretched their necks to reach higher branches for food, resulting in longer necks during an individual's lifetime.
3. This acquired longer neck trait was passed to offspring, and successive generations have longer necks for reaching higher branches.



Lamarck's theory was proven incorrect by modern genetics

We now know that characteristics acquired by an organism during its lifetime do not affect the DNA sequence of the organism and cannot be passed down from one generation to the next.

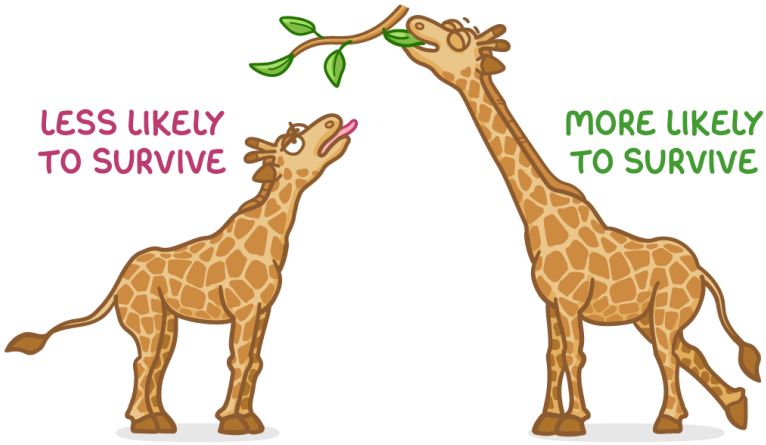
Charles Darwin made a number of important observations:

1. Individual organisms within a species show a wide range of variation for a specific trait.
2. Darwin observed variations between species adapted to different environments.
3. Older layers of rock contained fossils of less complex organisms, while more recent layers showed more complex organisms.

In his book, "On the Origin of Species", Darwin proposed that natural selection is the driving force behind the gradual development of species over time.

According to Darwins theory, giraffes have long necks because:

1. Some giraffes had longer necks than others, due to variation within the species.
2. Giraffes with longer necks were better adapted to their environment, as they could eat leaves from taller trees.
3. Giraffes with longer necks had a higher chance of surviving and reproducing, and passed on the trait of long necks to their offspring.
4. Over many generations, this process produced modern giraffes, with very long necks.



It took time for the theory of evolution to become widely accepted

Many people didn't accept Darwin and Wallace's theory, for several reasons:

- Religious reasons - Darwin's theory challenged the religious belief that God created all life forms.
- Lack of evidence - a lack of hard evidence made many scientists hesitant to accept Darwin & Wallace's theory.
- DNA hadn't been discovered yet - the mechanism for inheritance and variation, now understood through genetics, was unknown during Darwin's time.

<u>Independent practice</u>

1. Which three scientists have made theories on evolution?
2. What did Lamarck think organisms could do in their lifetime?
3. According to Lamarck, Why did giraffes have long necks?
4. Was Lamarck proven correct?
5. What do we now know about modern genetics?
6. What did Darwin observe?
7. What book did Charles Darwin write?
8. According to Darwin, Why did giraffes have long necks?
9. Extended writing; Discuss why it took time for the theory of evolution to become widely accepted.

L6 The Fossil Record

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 eventually become rock

Ammonite fossils, an example is shown here, are sea creatures that became extinct about 65 million years ago.

The 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.

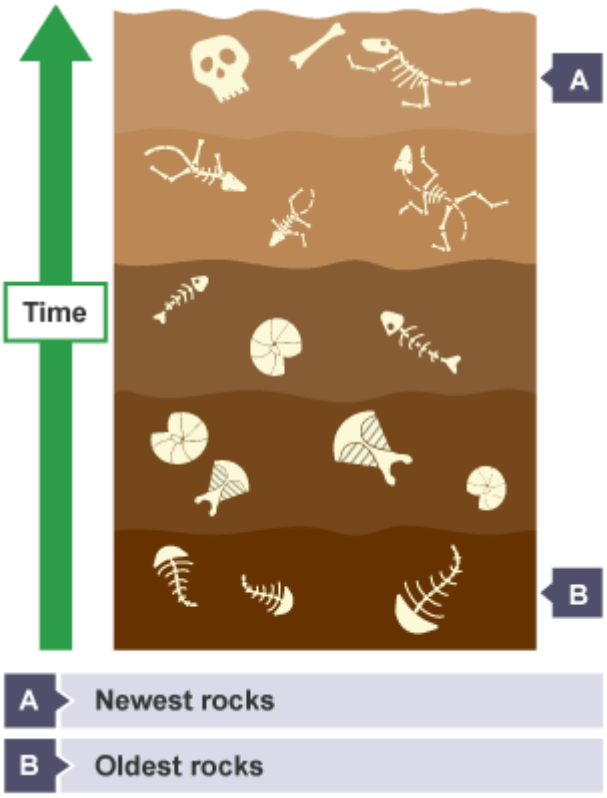
Evidence for early forms of life comes from fossils. By studying fossils, scientists can learn how much (or how little) organisms have changed as life developed on Earth.

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.

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.

<u>Independent practice</u>

1. What is a fossil?
2. What process does **not** happen for fossils to be made?
3. What are three ways a fossil can be formed?
4. What is the fossil record?
5. How does the fossil record support Darwin's theory of evolution?
6. What causes gaps in the fossil record?
7. What are some ways the dead remains of animals can be preserved?
8. How was the Lindow man formed?
9. Extended writing: Explain how the fossil record provides evidence that species change over time.