

The development of understanding of genetics and evolution

Revision notes · Darwin, Wallace and Mendel, evidence for evolution, fossils, extinction and antibiotic-resistant bacteria.

For AQA GCSE Biology 8461 and Combined Science: Trilogy 8464. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

The development of understanding of genetics and evolution **Spec 4.6.3**

Theory of evolution **Spec 4.6.3.1** **Triple only**

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

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

Darwin published his ideas in **On the Origin of Species** (1859). There was much controversy about these revolutionary new ideas. The theory developed over time, using information gathered by many scientists.

Why the theory was only gradually accepted

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

Lamarck

Other theories, including that of Jean-Baptiste Lamarck, 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.

Exam tip: Learn the three reasons for slow acceptance as a short list: religious belief, not enough evidence, no known mechanism of inheritance. A study of creationism is not required.

Speciation **Spec 4.6.3.2** **Triple only**

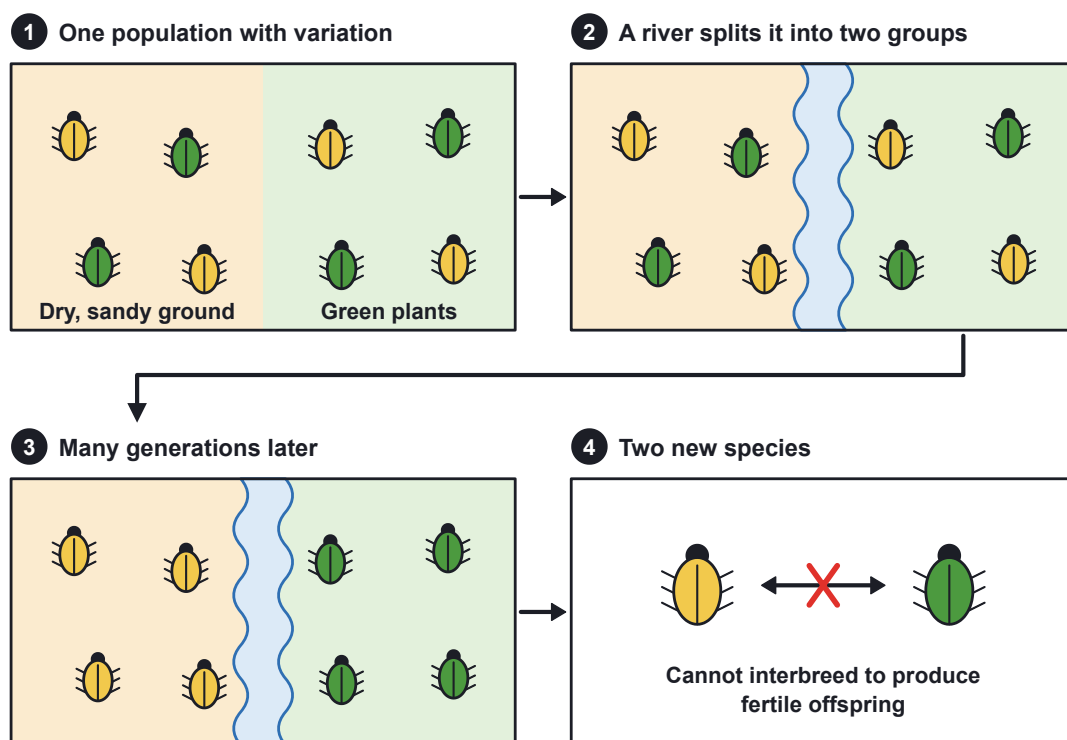
Alfred Russel Wallace independently proposed the theory of evolution by natural selection. He published **joint writings with Darwin in 1858**, which prompted Darwin to publish *On the Origin of Species* (1859) the following year.

Wallace worked worldwide gathering evidence for evolutionary theory. He is best known for his work on **warning colouration** in animals and his theory of speciation. More evidence over time has led to our current understanding of speciation.

The work of Darwin and Wallace had a big impact on biology. It gave a single explanation for how species change over time and how new species form, and it led to scientists collecting evidence to test the theory.

Steps that give rise to new species

1. A population of one species becomes **isolated** (for example by a geographical barrier), so the two populations cannot interbreed.
2. There is genetic variation in each population, arising from mutations.
3. The two populations live in different environments, so natural selection acts differently on them. Individuals with characteristics best suited to each environment survive and breed.
4. The alleles for these characteristics are passed on, so the populations change over many generations.
5. Eventually the populations are so different in phenotype that they can **no longer interbreed to produce fertile offspring**. They are now two new species.



Isolation plus different natural selection on each side leads to two populations that can **no longer interbreed to produce fertile offspring**.

The understanding of genetics Spec 4.6.3.3 Triple only

Our current understanding of genetics has developed over time, from the work of many scientists. This led to the **gene theory**.

Development of the gene theory

When	What happened
Mid-19th century	Gregor Mendel carried out breeding experiments on plants. He observed that the inheritance of each characteristic is determined by 'units' that are passed on to descendants unchanged.
Late 19th century	The behaviour of chromosomes during cell division was observed.
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.
Mid-20th century	The structure of DNA was determined and the mechanism of gene function worked out.

Why Mendel's work was not recognised until after his death

When Mendel published his results, the behaviour of chromosomes during cell division had not yet been observed. Nobody knew of any structure in cells that his 'units' could be, so there was no way to explain how they were passed on. The link between chromosomes and his 'units' was only made in the early 20th century, after his death. Few scientists read or understood his work at the time.

Exam tip: For 'why was Mendel's work not recognised', the key idea is that chromosomes and their behaviour in cell division had not been observed when he published, so his 'units' could not be linked to any structure in cells.

Evidence for evolution Spec 4.6.3.4

The theory of evolution by natural selection is now **widely accepted**. Evidence for Darwin's theory is now available. You need to be able to describe the evidence, including fossils and antibiotic resistance in bacteria.

- It has been shown that **characteristics are passed on to offspring in genes**.
- The **fossil record** provides further evidence (see the next section).
- Knowledge of how **resistance to antibiotics evolves in bacteria** provides evidence that natural selection happens and can be seen in a short time (see Resistant bacteria).

Exam tip: Link your evidence to the theory. Say what is seen (for example fossils show how organisms have changed), then say how it supports evolution by natural selection.

Fossils Spec 4.6.3.5

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

How fossils may form

- 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.

We can learn from fossils how much or how little different organisms have changed as life developed on Earth.

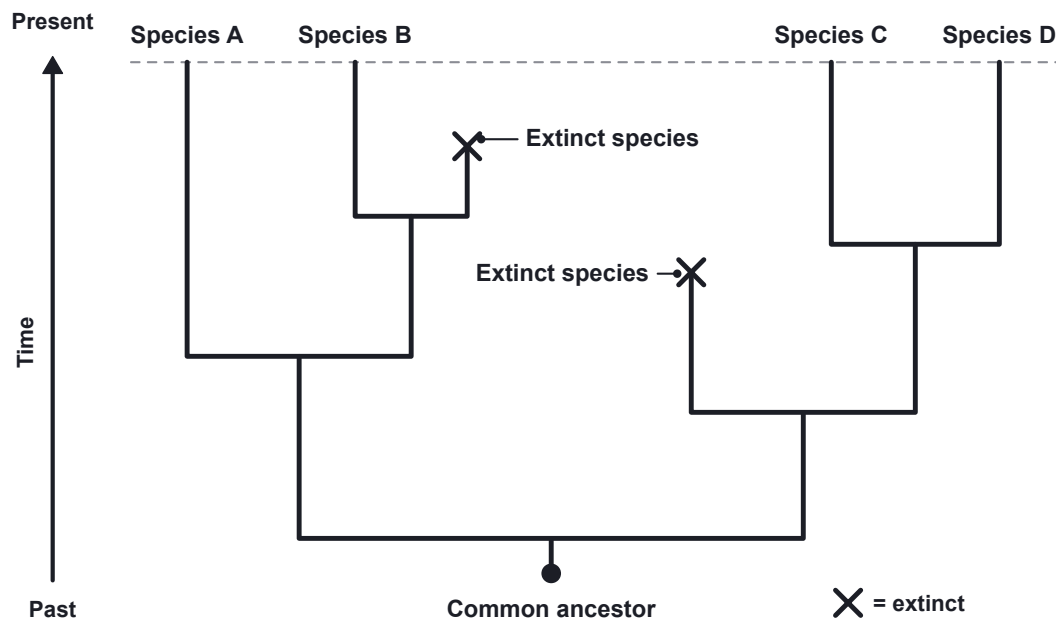
Why the fossil record is incomplete

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 about how life began on Earth.

Evolutionary trees

You may need to extract and interpret information from charts, graphs and tables, such as evolutionary trees. Evolutionary trees use fossil data for extinct organisms and current classification data for living organisms.

Exam tip: Fossils are evidence for how organisms have changed over time, but gaps mean the record is incomplete. Quote both ideas in an evaluation.



Branches ending in a cross are **extinct** species, known only from fossils.

Extinction Spec 4.6.3.6

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

You need to be able to describe factors that may contribute to the extinction of a species. A species may become extinct because of:

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

Exam tip: Always link the factor to the species: for example, a new disease kills individuals faster than they can reproduce, so the numbers fall until none are left.

Resistant bacteria Spec 4.6.3.7

Bacteria can evolve rapidly because they **reproduce at a fast rate**. Mutations of bacterial pathogens produce new strains.

1. A mutation produces a strain that is resistant to antibiotics.
2. When antibiotics are used, non-resistant bacteria are killed. The resistant bacteria are not killed.
3. The resistant bacteria **survive and reproduce**, so the population of the resistant strain rises.
4. The resistant strain spreads, because people are not immune to it and there is no effective treatment.

MRSA is resistant to antibiotics.

Reducing the rate of development of resistant strains

- Doctors should **not prescribe antibiotics inappropriately**, such as for non-serious or viral infections.
- Patients should **complete their course** of antibiotics so all bacteria are killed and none survive to mutate and form resistant strains.
- The **agricultural use** of antibiotics should be restricted.

The development of new antibiotics is costly and slow. It is unlikely to keep up with the emergence of new resistant strains.

Common mistake: People do not become resistant to antibiotics. The bacteria are resistant. The resistant bacteria survive and reproduce, passing on the resistance.

Quick check

1. **Triple only** Give two reasons why Darwin's theory was only gradually accepted.
2. **Triple only** Who published joint writings with Darwin in 1858?
3. Why is the fossil record incomplete?
4. Why do resistant strains of bacteria spread so quickly?
5. Give one way to reduce the development of antibiotic resistance.

Quick check answers

The development of understanding of genetics and evolution

- 1 . Any two of: it challenged the idea that God made all animals and plants; there was insufficient evidence; the mechanism of inheritance was not known.
- 2 . Alfred Russel Wallace.
- 3 . Early life was soft-bodied and left few traces, and many traces were destroyed by geological activity.
- 4 . Bacteria reproduce quickly, people are not immune and there is no effective treatment.
- 5 . Do not prescribe antibiotics inappropriately, complete the course, or restrict agricultural use.