

Darwin, natural selection and antibiotic resistance

Revision notes · How Darwin and Wallace developed the theory of evolution by natural selection, and how antibiotic-resistant bacteria support it.

For Edexcel GCSE Biology 1BI0 and Combined Science 1SC0. **Triple only** is not in Combined Science. **Higher tier** is only on the Higher paper.

Darwin, natural selection and antibiotic resistance Spec 4.1B-4.3

The work of Darwin and Wallace Spec 4.1B Triple only

The theory of **evolution by natural selection** was developed by two scientists working separately: Charles Darwin and Alfred Wallace.

Charles Darwin

- Darwin collected observations and specimens on a long sea voyage, including studying plants and animals in different places.
- He noticed that individuals of the same species show variation, and that organisms in different places are suited to their different environments.
- He spent many years collecting evidence and developing his ideas before publishing them in his book *On the Origin of Species* in 1859.

Alfred Wallace

- Wallace independently developed a very similar theory of evolution by natural selection.
- His ideas were based on his own observations and collections of plants and animals in different parts of the world.
- His work encouraged Darwin to publish, and the two men's ideas were presented together.

Impact on modern biology

- Natural selection gave a **unifying explanation** for the huge diversity of living things and how species are related.
- When combined with later knowledge of genes, it explains how **variation** arises (through mutation) and how characteristics are inherited.
- It helps us understand the emergence of resistant organisms, such as antibiotic-resistant bacteria.
- It supports the idea that living things can be classified according to how they are related.

Exam tip: If asked about Wallace, say he developed the theory independently of Darwin. Do not say he copied or helped Darwin write the book.

Evolution by natural selection Spec 4.2

Evolution is a change in the inherited characteristics of a population over many generations. Darwin explained how it happens using natural selection.

1. Individuals in a population show **variation**. Some of this is genetic, caused by differences in alleles, which arise by **mutation**.
2. More offspring are born than can survive, so individuals **compete** for resources such as food, space and mates, and some are eaten or die of disease.

3. Individuals with characteristics that suit their environment are more likely to **survive and reproduce**.
4. They **pass on the alleles** for those characteristics to their offspring.
5. Over many generations, the proportion of the population with the advantageous alleles increases.

Individuals with a characteristic that gives an advantage are sometimes described as the 'fittest'. This means best suited to their environment, not strongest.

Natural selection	The process by which organisms better adapted to their environment are more likely to survive, reproduce and pass on their alleles.
Evolution	A change in the inherited characteristics of a population over many generations.

Common mistake: Individuals do not change during their lives to cope with their environment. The advantageous allele has to be there already, and the proportion of individuals with it increases over generations.

Exam tip: Write the full chain in your answer: variation (from mutation), survival and reproduction of the better adapted, alleles passed on, proportion increases.

Resistant organisms and antibiotic resistance Spec 4.3

The emergence of **resistant organisms** is an example of natural selection that can be seen happening within a human lifetime. Bacteria reproduce very quickly, so changes in a population happen fast.

1. In a population of bacteria, a **mutation** produces an allele that makes one bacterium resistant to an antibiotic. This is variation.
2. The antibiotic is used. It kills the non-resistant bacteria, but the resistant bacterium survives. The antibiotic is the **selection pressure**.
3. The resistant bacterium reproduces with less competition, and passes the resistance allele on to its offspring.
4. Over time the population is mostly resistant bacteria, so the antibiotic no longer works against the infection.

This supports Darwin's theory because all the steps of natural selection can be observed: variation, a selection pressure, survival and reproduction of the better adapted, and inheritance of the useful allele.

Percentage of resistant bacteria (practice data)

In a lab, 300 bacteria were sampled before treatment and 12 were resistant to an antibiotic. After several rounds of treatment, 300 bacteria were sampled again and 192 were resistant. Calculate the percentage resistant at each time, and the change.

1. Before: $12 \div 300 \times 100 = 4\%$
2. After: $192 \div 300 \times 100 = 64\%$
3. Change: $64 - 4 = 60$ percentage points

Answer: 4% before, 64% after, an increase of 60 percentage points.

Maths skill: You may be asked to plot such data as a bar chart or line graph. Choose scales that use at least half the grid, label both axes with units, and plot the independent variable (time or treatment) on the x-axis.

Common mistake: Antibiotics do not cause the mutation, and bacteria do not 'get used to' antibiotics. The resistant bacteria were there by chance and are selected by the antibiotic.

Quick check

- 1 . What causes new alleles to appear in a population?
- 2 . Give the four main steps of natural selection in order.
- 3 . In antibiotic resistance, what is the selection pressure?
- 4 . Why do populations of bacteria change quickly?

Quick check answers

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- 1 . Mutation.
- 2 . Variation, competition so some survive and reproduce, alleles passed on, proportion with the useful allele increases.
- 3 . The antibiotic.
- 4 . Bacteria reproduce very rapidly, so the resistance allele spreads in a short time.