

# Chapter 15: Genetics and evolution

## Knowledge organiser

### Theory of evolution

**Evolution** is the gradual change in the inherited characteristics of a population over time.

Evolution occurs through the process of **natural selection** and may result in the formation of new species.

Darwin published this theory in *On the Origin of Species* (1859). His ideas were considered controversial and only gradually accepted because

- they challenged the idea that God made all of the Earth's animals and plants
- there was insufficient evidence at the time the theory was published, although much more evidence has been gathered since
- mechanisms of inheritance and variation were not known at the time
- other theories, such as that of Jean-Baptiste Lamarck, were based on the idea that the changes that occur in an organism over its lifetime could be passed on to its offspring. We now know that in the majority of cases this type of inheritance cannot occur.

### Process of natural selection

The theory of evolution by natural selection states that

- organisms within species show a wide range of variation in phenotype
- individuals with characteristics most suited to the environment are more likely to survive and breed successfully
- these characteristics are then passed on to their offspring.

### Evidence for evolution

The theory of evolution by natural selection is now widely accepted because there are lots of data to support it, such as

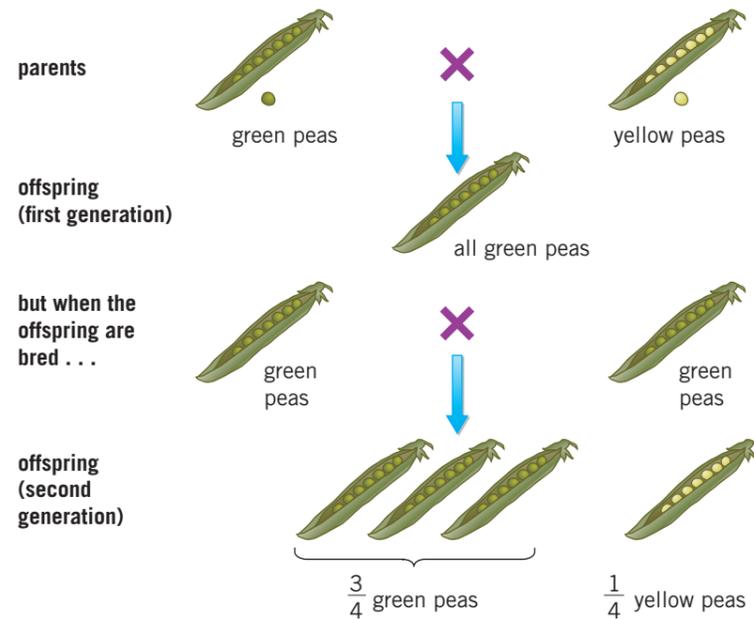
- it has been shown that characteristics are passed on to offspring in genes
- evidence from the **fossil record**
- the evolution of antibiotic resistance in bacteria.

### Extinction

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

Factors that may contribute to a species' extinction include

- new predators
- new diseases or pathogens
- increased competition for resources or mates
- catastrophic events (e.g., asteroid impacts, volcanic eruptions, earthquakes)
- changes to the environment (climate change, destruction of habitats).



### Development of gene theory

Further work by many scientists led to the development of **gene theory**.

In the late nineteenth century the behaviour of chromosomes during cell division was observed.

In the early twentieth century genes and chromosomes were observed to behave similarly, leading to the idea that genes were located on chromosomes.

In the mid-twentieth century the structure of DNA and mechanism of gene function were determined.

### Speciation

Alfred Wallace worked with Darwin to propose the theory of evolution by natural selection. He is also known for his work on the theory of **speciation**.

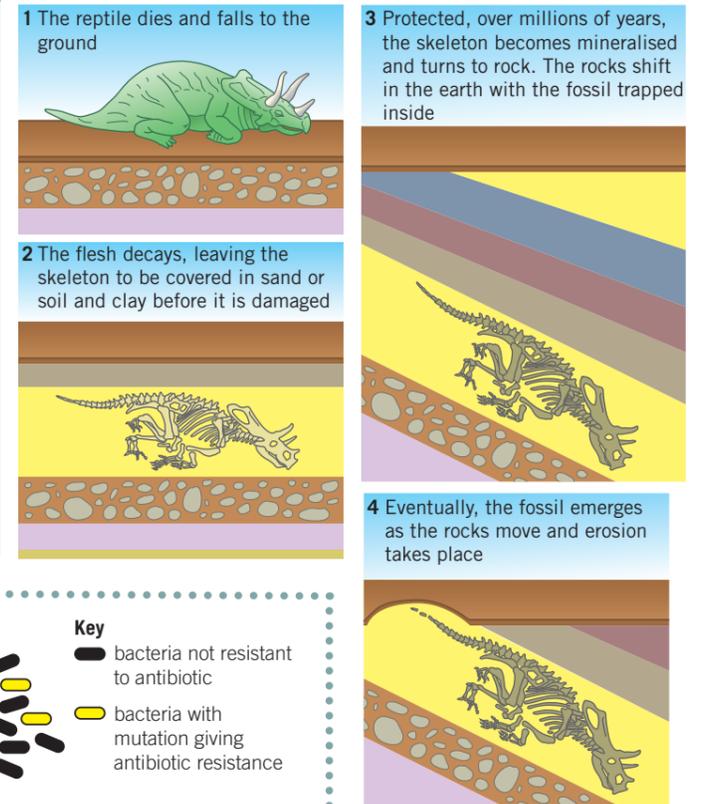
Speciation is the gradual formation of a new species as a result of evolution. More evidence and work from scientists over time have led to our current understanding of the theory of speciation.

#### Process of speciation

- 1 two populations of one species are isolated (e.g., by a river or mountain range)
- 2 natural selection occurs so that the better-adapted individuals reproduce and pass on these different characteristics
- 3 the populations have an increasing number of genetic mutations as they adapt to their different environments
- 4 eventually the two populations are so genetically different they cannot breed to produce fertile offspring

### Fossils

Benefits of the fossil record	Problems with the fossil record
<ul style="list-style-type: none"> <li>• can tell scientists how individual species have changed over time</li> <li>• fossils allow us to understand how life developed over Earth's history</li> <li>• fossils can be used to track the movement of a species or its ancestors across the world</li> </ul>	<ul style="list-style-type: none"> <li>• many early organisms were soft-bodied, so most decayed before producing fossils</li> <li>• there are gaps in the fossil record as not all fossils have been found and others have been destroyed by geological or human activity – this means scientists cannot be certain about how life began on Earth</li> </ul>

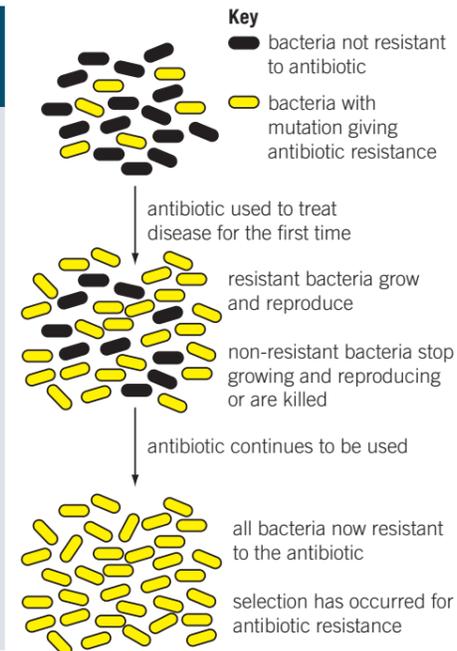


### Emergence of antibiotic resistance

The development of new antibiotics is expensive and slow, so is unlikely to keep up with the emergence of new antibiotic-resistant bacteria strains.

To reduce the rise of antibiotic-resistant strains

- doctors should only prescribe antibiotics for serious bacterial infections
- patients should complete their courses of antibiotics so all bacteria are killed and none survive to form resistant strains
- the use of antibiotics in farming and agriculture should be restricted.



### Key terms

Make sure you can write a definition for these key terms.

- evolution    extinction    fossil record    natural selection    speciation  
 antibiotic-resistance    gene theory

# Chapter 15: Genetics and evolution

## Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

### B15 questions

### Answers

1	What is evolution?	Put paper here	change in the inherited characteristics of a population over time through natural selection, which may result in a new species
2	Who first proposed the theory of evolution by natural selection?	Put paper here	Charles Darwin
3	What is the theory of evolution by natural selection?	Put paper here	all species of living things evolved from a common ancestor that developed billions of years ago
4	Describe Lamarck's idea of inheritance.	Put paper here	organisms change over their lifetimes and these characteristics can be inherited
5	Why was the theory of evolution by natural selection controversial?	Put paper here	<ul style="list-style-type: none"><li>• challenged the idea that God made all of Earth's animals and plants</li><li>• insufficient evidence at the time</li><li>• genes, inheritance, and variation were not understood</li></ul>
6	What is speciation?	Put paper here	gradual formation of a new species as a result of evolution
7	What evidence supports the theory of evolution?	Put paper here	<ul style="list-style-type: none"><li>• parents pass on their characteristics to offspring in genes</li><li>• fossil record evidence</li><li>• evolution of antibiotic-resistant bacteria</li></ul>
8	What did Mendel discover through breeding experiments on plants?	Put paper here	inheritance of characteristics is determined by units (genes) passed on unchanged to offspring
9	What are fossils?	Put paper here	remains of organisms from millions of years ago, found in rocks
10	How might fossils be formed?	Put paper here	<ul style="list-style-type: none"><li>• parts of an organism do not decay because the conditions needed for decay are absent</li><li>• traces of organisms are preserved</li><li>• parts of an organism are replaced by minerals</li></ul>
11	What are the benefits of the fossil record?	Put paper here	can learn how species changed and life developed on Earth, and can track the movement of species across the world
12	What are the problems with the fossil record?	Put paper here	<ul style="list-style-type: none"><li>• many early organisms were soft-bodied so left few fossils</li><li>• gaps in the fossil record as not all fossils have been found and some have been destroyed</li></ul>
13	What is extinction?	Put paper here	no individuals of a species are still alive
14	What is the binomial system?	Put paper here	naming of organisms by their genus and species
15	What classification system did Carl Woese introduce?	Put paper here	three-domain system of Archaea, Bacteria, and Eukaryota
16	Why can bacteria evolve rapidly?	Put paper here	they reproduce at a fast rate
17	How do antibiotic-resistant strains of bacteria develop?	Put paper here	mutations that allow the strain to survive and reproduce