



Evolutionary Theory

BIOLOGY • ADAPTATION AND EVOLUTION • EVOLUTIONARY THEORY

Section 1: Evolution

• What is evolution?

Evolution is the process by which species can change and adapt over time. It is also the process by which new species are formed from pre-existing ones. It involves a change in the frequency of certain genes in a population over time.

For example, over time a population of organisms may change to become better adapted to its conditions. They may become resistant to disease or better camouflaged. In some cases, a population may change so much that it becomes a different species.

• Suggested Film

– Natural Selection

Extension Question

Q1. Is it possible to observe evolution?

Evolution isn't something that happens before your eyes. It takes place in a population of organisms over a number of generations. In some cases this may take thousands or even millions of years, so it is not observable in the classic sense. In other cases it can be seen to happen over much shorter periods of time, especially in those species that have very short life cycles, like bacteria and some insects.



Giraffes have evolved with long necks, as the organisms with the longest necks are able to reach the tallest leaves and are more likely to survive

• How does evolution happen?



The black peppered moth (left) had a selective advantage over the white peppered moth (right) as it could hide from predators against pollution stained rocks

It is generally accepted that evolution occurs through a process of natural selection. In any population of organisms we can observe differences. For example, some organisms are stronger, some are more resistant to disease, and some are more attractive to mates.

Under certain conditions, these differences provide an advantage to an organism, giving it a better chance of surviving and reproducing. If the differences are determined by genetics, they can be passed on to the next generation, which in turn may pass them on to their offspring. As a result, over time a change in the gene frequency of the population can occur, and we can say that the population is evolving.

• Suggested Films

- Natural Selection
- Man's First Ancestors
- Homo Habilis and Boisei
- Homo Ergaster
- Homo Sapiens

Extension Question

Q2. What is genetic drift?

Whereas gene frequencies in a population typically change due to survival and reproductive advantages, they can also change due to chance events. For example, organisms may survive and reproduce due to chance rather than to being better suited to the conditions. When this happens we say evolution is happening due to genetic drift. It is most easily observable in small populations.

• What causes new features to emerge in a population?

The differences, or variations, that we observe in populations are caused by both genetic and environmental factors. For example, someone's blood group is determined by genetic factors, whereas someone's weight is caused by a combination of genetic and environmental factors. Only genetic factors can be passed down from generation to generation when organisms reproduce. New genetic characteristics are caused when DNA mutates, creating a new gene. If this new characteristic is advantageous, then the gene determining it may increase in frequency within the population due to the process of natural selection.

• Suggested Films

– Mechanisms of Evolution

Extension Question

Q3. Are mutations good or bad?

Mutations can lead to characteristics which are advantageous. If this is the case, these mutations will be selected for and so become more common in the gene pool. However, mutations may also disadvantage an organism, in which case they are likely to be selected against, and so decrease in frequency. Both these processes underpin and drive evolution.

Section 2: Forming New Species

• What is a species?

A species is a population of organisms capable of interbreeding to create fertile offspring. Members of the species show similarities in their genetics, behaviour and appearance.

For example, cheetahs are a species of big cat, they look very similar to each other and are able to interbreed. Lions are a different species of big cat, they can breed with one another, but they are unable to breed with cheetahs.

• Suggested Films

– FactPack: Hybrid Animals

– FactPack: Primitive Species



The lion is a specific species of big cat, different to other species such as cheetahs and jaguars

Extension Question

Q4. Are donkeys and horses different species?

Donkeys and horses look and behave in very similar ways suggesting they are closely related, they can even mate with one another! However, the offspring they produce, called mules, are infertile. This means that there is no gene mixing over time between donkeys and horses, and therefore they are classified as different species.

• How are new species formed?

New species can be formed when populations of the same species become separated from each other, and reproduction between them ceases. These different populations can then evolve in different ways in response to different selection pressures. Over time, the populations might diverge so much that they have become new species, no longer able to interbreed, and often showing differences in their genetics, appearance and behaviour.

- **Suggested Film**
 - **Origin of Species**

Extension Question

Q5. Are lions and tigers closely related?

Yes. Much of their DNA is identical, and it is believed they shared a common ancestor over 6 million years ago. Two populations of this ancestor were geographically separated, each then evolved and diverged in isolation, leading to the formation of the two species.

• Who proposed the theory of evolution by natural selection?

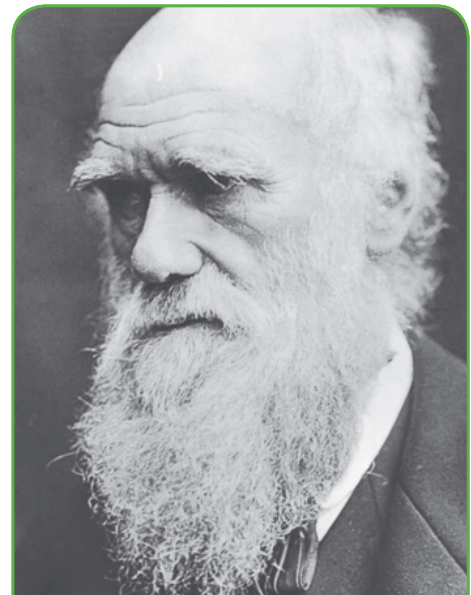
Charles Darwin is credited with the theory of evolution by natural selection. He developed his theory during the middle of the 19th century, following his observations of the natural world. His book *The Origin of Species* was published in 1859 and it caused significant controversy at the time, as it challenged the view that God had created all the different forms of life on Earth. It also implied that all living things shared a common ancestor, and that humans had evolved from apes. Many people at the time found this deeply distasteful.

- **Suggested Films**
 - **Darwin's Dilemma**
 - **Chimps: Our Closest Relatives?**

Extension Question

Q6. How different are humans and chimps?

The DNA of humans and chimps is 98% identical. It is believed we shared a common ancestor about 5 million years ago.



Charles Darwin proposed the theory of evolution in the 19th century

Section 3: Evidence for Evolution

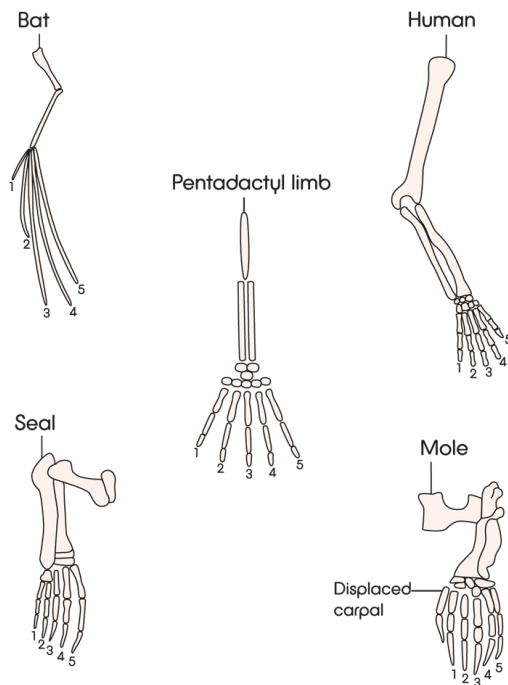
- What is the evidence for evolution?

DIAGRAM 01:



Evolution of the Pentadactyl Limb

BIOLOGY • ADAPTATION AND EVOLUTION • EVOLUTIONARY THEORY



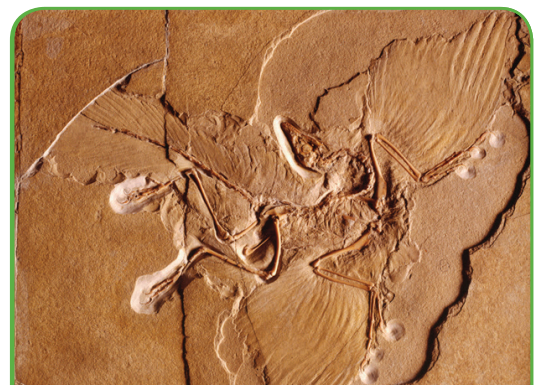
Fossils are the remains of organisms preserved in the rocks. We are able to date fossils, and so they provide a record of what lived on Earth many millions of years ago. They show a gradual change in living things, from simple to more complex forms, and they also provide evidence for intermediate forms between different groups of organisms.

We can also observe similarities between living organisms. For example, the skeletons of all mammals are remarkably similar and also not very different from those of birds and reptiles! In a similar way the genes of closely related species are much more similar than those of very different ones, supporting the idea of common ancestry.

We can also see evolution in action, especially in those species that have short life cycles. We have observed insects becoming resistant to chemical insecticides, and squirrels evolving in response to climate change, for example.

• Suggested Film

- Evolution: The Evidence
- Early Man and Agriculture
- Evolution of Man: The Evidence



This Archaeopteryx fossil combines aspects of dinosaur anatomy and aspects of modern bird anatomy, suggesting that birds have evolved from reptiles

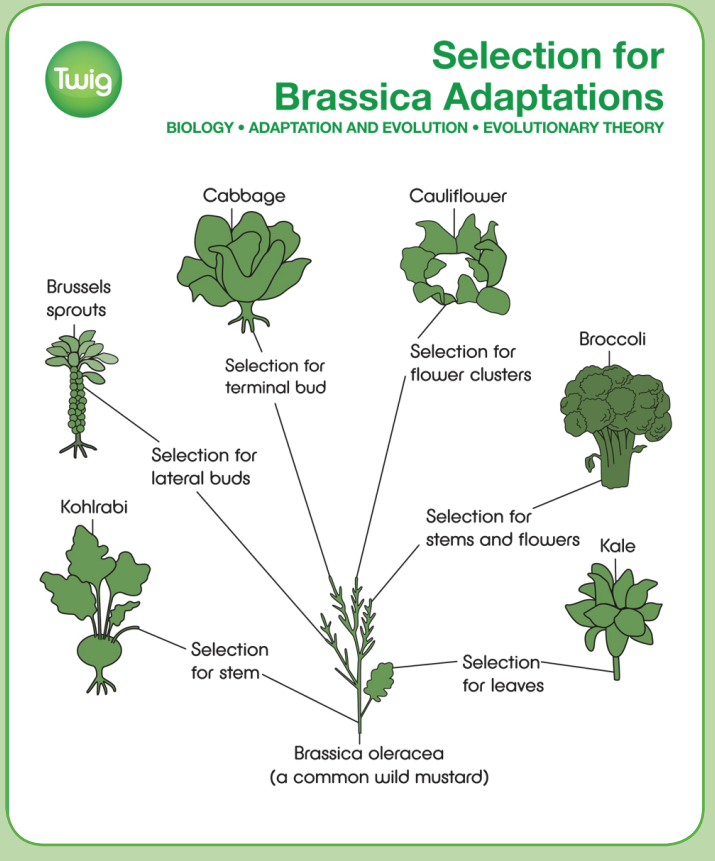
Extension Question

Q7. How do bacteria evolve to become resistant to antibiotics?

Antibiotics are chemicals used to kill bacteria. Although they are usually extremely effective at doing this, there are occasionally bacteria which survive because they show slight differences in their structure and chemistry. Those that survive go on to reproduce to form a population of resistant organisms. This is an example of evolution in action.

• What is artificial selection?

DIAGRAM 02:



Racing greyhounds are often selected for speed and the fastest individuals are chosen for breeding

Man is able to deliberately drive an evolutionary process. This is called artificial selection and it involves humans, rather than nature, selecting those organisms which will breed and pass on their genes.

For example, farmers often select their best animals for breeding in order to improve the quality of the offspring with respect to characteristics, like meat yield and disease resistance. Similarly, dog breeders often breed animals with desired characteristics, such as coat colour and body shape, in the hope that the offspring will be like their parents. Again, this is strong evidence that a natural process is able to drive evolution in the natural world.

• Suggested Films

- FactPack: Selective Breeding
- Silver Foxes: Breeding and Behaviour

Extension Question

Q8. What is eugenics?

Eugenics is the science of 'improving' the human gene pool by controlling who can and cannot reproduce. In simple terms, it would involve preventing those with 'undesirable' characteristics from breeding, and promoting the reproduction of those with 'desirable' features. It was popular in the early 20th century, but is now regarded as unethical.

• Are species always evolving?

A population evolves when there is a selection pressure which can act on the variations within that population. If conditions are ideal then there is little pressure to select one individual over another. The fossil record indicates that there are periods when species show very little change, but also periods when there can be rapid and dramatic evolution occurring, presumably in response to significant environmental selection pressure.

• Suggested Film

– **FactPack: Primitive Species**

Extension Question

Q9. Could global warming lead to rapid evolution of species?

An increase in environmental temperature can certainly provide a powerful selection pressure. Some organisms in a population will be better adapted to cope with such changes than others. Those better adapted are more likely to survive and reproduce, thereby passing on their genes to the next generation. There is substantial evidence that certain species, including some birds and insects, have evolved in response to the global warming of the past 150 years.

• Quizzes

Evolutionary Theory

Basic

• Who proposed the theory of evolution by natural selection?

- A – Richard Dawkins
- B – Charles Darwin
- C – Isaac Newton
- D – Albert Einstein

• What is a mutation?

- A – variation in an organism
- B – a change in the DNA of a cell
- C – a change in the behaviour of a cell
- D – a change in the appearance of an organism

• What causes a species to adapt to its environment?

- A – mutation
- B – genetic drift
- C – natural selection
- D – genetic variation

Advanced

• What is evolution?

- A – a change in the appearance of an organism
- B – a change in the appearance of a population
- C – a change in the gene frequency of a population
- D – a change in the genes of an organism

• What is a mutation?

- A – variation in an organism
- B – a change in the DNA of a cell
- C – a change in the behaviour of a cell
- D – a change in the appearance of an organism

• What causes a species to adapt to its environment?

- A – mutation
- B – genetic drift
- C – natural selection
- D – genetic variation

• What causes a change in gene frequency in a population due to chance events?

- A – mutation
- B – genetic drift
- C – natural selection
- D – genetic variation

• Answers

Evolutionary Theory

Basic

• Who proposed the theory of evolution by natural selection?

A – Richard Dawkins

B – Charles Darwin

C – Isaac Newton

D – Albert Einstein

• What is a mutation?

A – variation in an organism

B – a change in the DNA of a cell

C – a change in the behaviour of a cell

D – a change in the appearance of an organism

• What causes a species to adapt to its environment?

A – mutation

B – genetic drift

C – natural selection

D – genetic variation

Advanced

• What is evolution?

A – a change in the appearance of an organism

B – a change in the appearance of a population

C – a change in the gene frequency of a population

D – a change in the genes of an organism

• What is a mutation?

A – variation in an organism

B – a change in the DNA of a cell

C – a change in the behaviour of a cell

D – a change in the appearance of an organism

• What causes a species to adapt to its environment?

A – mutation

B – genetic drift

C – natural selection

D – genetic variation

• What causes a change in gene frequency in a population due to chance events?

A – mutation

B – genetic drift

C – natural selection

D – genetic variation