Student book answers

2.1 Darwin and Wallace were co-conspirators

Pages 40–43

Extend your understanding 2.1

1 One of the biggest questions asked by humans is ‘Where did we come from?’ How have different people answered that question?

‘Where did we come from’ can be approached from two directions: the short-term answer (from your mother and father) and the long-term answer (humans shared a common ancestor with apes). Some people answer both these questions with a general answer: ‘God created us all’.

2 Charles Darwin wasn’t the first person to propose the idea of evolution. What was Lamarck’s hypothesis about the way evolution worked?

Lamarck believed that organisms change in their lifetime due to changing environmental conditions. He proposed that these changes were passed on to their offspring.

3 What was it about the tortoises of the Galapagos Islands that helped Darwin develop his ideas about evolution and natural selection?

The Island’s vice-governor told Darwin that he could tell which island the tortoise came from by the shape of the tortoise’s shell. This left Darwin wondering why this might be the case.

4 What features of the finches showed similarity in form?

All the finches had similar beaks, body shape and feathers.

5 Why do you think Darwin waited so long between arriving at his hypothesis and publishing his theory on evolution?

Darwin was creating a theory that was contrary to the current views on diversity. He wanted enough evidence to ensure people would seriously consider his hypothesis.

6 Draw a timeline of ideas before and after evolution.

Key points in the timeline should include:

• 1790: William Smith identified unknown fossils and dated them.

• 1796: Georges Cuvier argued that the fossils belonged to organisms that were made extinct by a catastrophe.

• 1801: Jean-Baptiste de Lamarck proposed that if an organism changes during its lifetime in order to adapt, these changes are passed on to its offspring.

• 1832: Charles Darwin sailed on the Beagle and made observations about the organisms on the Galapagos Islands.

• 1837: Darwin finished his journal The Voyage of the Beagle and started breeding pigeons.

• 1858: Darwin and Wallace separately published their scientific papers on natural selection.

• 1859: Darwin’s On the Origin of Species was published.

7 Do you think it is fair that Darwin receives all of the credit for the theory of evolution? Justify your answer.

Student answers’ will vary.

For example: No, it is not fair because both Darwin and Wallace published their almost identical papers on natural selection as the mechanism for evolution at the same time; therefore, they should receive equal credit.

8 Discuss why, for various reasons, the theory of evolution has been controversial for some people.

Student answers will vary. Most commonly the theory of evolution causes people to question their religious beliefs.

Student book answers

2.2 Natural selection is the mechanism of evolution

Pages 44–45

Check your learning 2.2

Remember and understand

1 Variation in individuals can occur in different ways, but there is only one way in which new alleles can arise. What is this process called?

Mutation causes new alleles to be made.

2 Darwin made a series of inferences based on observations he made over 20 years. Link each of Darwin’s observations with the appropriate inference he made.

Observation 1: Members of a species are often different from each other. 🡪 In the struggle to survive, those individuals that are most suited to their environment survive.

Observation 2: There are always more children than parents. 🡪 In the struggle to survive, those individuals that are most suited to their environment survive.

Observation 3: The size of a population does not change. 🡪 In the struggle to survive, those individuals that are most suited to their environment survive.

Observation 4: Some offspring do not survive (survival of the fittest). 🡪 Those individuals that survive pass their traits on to their children.

Observation 5: Offspring look like their parents. 🡪 Those individuals that survive pass their traits on to their children.

3 Describe the selection pressures that caused the allelic frequency of light-grey moths to decrease in England in the 1950s.

An increase in pollution resulted in black soot on tree trunks. Less camouflage increased the chances of these light-coloured moths being eaten by predators, consequently reducing the frequency of the light-colour allele in the population.

4 In your own words, describe the mechanism by which natural selection can influence the frequency of alleles in a population.

There is a variation of alleles in any population. Some alleles give the organism a greater chance of survival. As a result, the organism is more likely to survive and pass their alleles on to the next generation. The frequency of the alleles in the population will change as a result.

Apply and analyse

5 Natural selection cannot increase or decrease the frequency of some mutations in a population. Why is this?

Neutral mutations do not give an individual an advantage or disadvantage in survival. As a result, their frequency will not change with natural selection.

Student book answers

2.3 Different selection pressures cause divergence. Similar selection pressures cause convergence

Pages 46–47

Check your learning 2.3

Remember and understand

1 Give an example of how physical isolation could create a new species.

A hurricane can result in organisms (such as iguanas) moving to another island. These organisms then interbreed and, as a result of pressures from different types of shelters and different foods, the allelic frequencies change (for example, the iguanas may become smaller). New mutations can arise in both the new and original populations such that they are no longer able to interbreed.

2 How does gene flow influence the process of speciation?

If gene flow occurs, the two populations share and exchange alleles and change together. If there is no gene flow, there is no sharing of alleles (including new alleles). This results in different allelic frequencies and, hence, eventually new species.

3 Define the term ‘homologous structures’.

Homologous structures are the features that are similar between different species due to a recent common ancestor, despite the features having different uses now.

4 Give an example of an analogous structure.

Arms and fingers, legs and toes

Apply and analyse

5 Describe how the land ancestors of dolphins evolved to become the streamlined mammals we see now.

Different selection pressures within an aquatic environment meant that individuals with traits that were beneficial in this environment, such as streamlined body shape, were selected for. These individuals were selected for, interbred and passed on these traits to their offspring.

Student book answers

2.4 Fossils provide evidence of evolution

Pages 48–51

Check your learning 2.4

Remember and understand

1 What parts of organisms are most likely to be found in fossils? Explain your answer.

The hard parts of an organism are more likely to be found because they are less likely to be broken down by bacteria or eaten by other organisms. As a result, the hard bits (bones) will be buried and gradually replaced by mineralisation.

2 How does relative dating work? Why is it often used before absolute dating is used?

Comparative dating is a judgement that a fossil is older or younger than a previously found fossil. This is often done by determining how deep underground the fossil was found. This is easier to do than to make a chemical analysis of the fossil itself.

3 Describe a transitional fossil.

Transitional fossils show some characteristics of both types of organisms as they changed gradually from one from to another.

4 Living fossils have remained relatively unchanged, often for millions of years, while around them other species have adapted or become extinct. How has this been possible?

Living fossils usually live in an environment that has not changed for a long time. This means that the selection pressures are also unchanged and therefore the organism does not have to adapt to new circumstances.

Apply and analyse

5 Will the theory of evolution ever become fact? Explain your answer.

A theory is a hypothesis that has been verified by many separate and tested observations. A fact is an objective and verifiable observation. Therefore, a theory is based on a series of facts. For this reason, evolution will always be a theory because it is an explanation of observable facts.

6 How might observations of extant (living) organisms contribute to the evidence for evolution?

Extant (or living) fossils are usually found in environments that have remained unchanged for millions of years. This means the selection pressures on these organisms have not changed; therefore, there is no need for the allelic frequencies to change or evolve.

7 Fossils were found at four locations (Figure 2.18). Use relative dating to determine which location had the oldest fossil.

The oldest fossils would be found at Location 4 because deeper layers were present.

Student book answers

2.5 Multiple forms of evidence support evolution

Pages 52–55

Check your learning 2.5

Remember and understand

1 The frogs in Australia show their closest evolutionary relationships to frogs in Africa and South America. How is this possible? Did humans carry them on boats?

The continents of Australia, Africa and South America were once linked as Gondwana. An ancestor of the frogs lived at that time. When the continents separated, each frog evolved but maintained the same basic features. Humans did not carry them on boats.

Apply and analyse

2 If native marsupials were found in North America, would this disprove the theory of continental drift? Explain your answer.

Australia was joined to South America on Gondwana when marsupials evolved. When Gondwana broke apart, there were marsupials on most of the continents. The marsupials on Australia were able to evolve into the marsupials we see today. The marsupials on the other countries became extinct, except for the South American opossum. This marsupial eventually migrated to North America.

3 How does the presence of vestigial structures support the theory of evolution?

Vestigial structures are now interpreted as evidence of an ancestral heritage in which these structures once performed other tasks.

4 Why do human embryos temporarily develop gill-like structures?

Human embryos develop gill-like structures and tails during their early development because they have the genes for these structures. These genes get switched off later on in embryonic development.

5 How can the gene that forms fingers be changed to form the wings on a bat?

The gene for a bat’s fingers become ‘supercharged’ during embryological development so that the fingers start growing faster than the rest of the body, which makes the fingers of the bat extra-long compared with the rest of its body.

6 Geologists are identifying ancient magnetic rocks that suggest magnetic north has moved over millions of years. How could this information be used to support the theory of continental drift? How could it impact the theory of evolution?

If magnetic north has moved in a pattern that is consistent with what is known about continental drift, then it will support the theory of continental drift. Because this theory also supports the theory of evolution, then the movement of magnetic north will also support the theory of evolution.

Student book answers

2.6 DNA and proteins provide chemical evidence for evolution

Pages 56–57

Check your learning 2.6

Remember and understand

1 What smaller (bead-like) structures make up proteins?

Amino acids

2 Cytochrome c is of interest to biologists studying evolution. What is the function of this molecule?

Cytochrome c is found in the inner membrane of the mitochondria of a cell. It plays an important role in energy production in the cell by transporting electrons along the mitochondrial cristae membrane.

3 Table 2.1 shows a small section of the cytochrome c molecule for humans, chickens, lungfish and flies. Which species shows the greatest similarity to humans? Explain your answer.

Chickens show the greatest similarity as only one amino acid is different within the sequence, whereas the other species have two different amino acids compared with humans.

4 What causes gradual changes to the sequence of nucleotides in DNA?

Genetic mutations

Apply and analyse

5 Use the phylogenetic tree on the right to determine which species is most closely related to species A.

Species B

6 Explain how DNA sequencing supports the concept of evolution from a common ancestor.

The DNA of all living organisms uses the same nucleotides and the same structure. This indicates a common ancestor. Many DNA sequences in the genes of essential proteins are conserved. This also indicates a common ancestor.

Student book answers

2.7 Humans artificially select traits

Pages 58–59

Check your learning 2.7

Remember and understand

1 What is selective breeding?

Selective breeding suggests that humans select animals based on the characteristics they require, and these animals are then bred to produce offspring.

2 Give an example of how selective breeding was used to produce an animal.

Many animal breeders use controlled breeding of pets and farming animals to obtain the most desired outcome. Examples students may use include dog breed: the American pit bulls were breed for muscular strength and the temperament of the animal was largely ignored; pug dogs with large folds around their face were chosen for preferred breeding in the past until it was realised that the folds can limit their eyesight, hearing and breathing; and the dachshund was bred on the basis of body length, until it was realised that this caused back and hip problems that are prominent in the breed today.

3 What is MRSA?

MRSA is a deadly species of bacteria that are fully resistant to antibiotics.

Apply and analyse

4 How can misusing antibiotics contribute to the existence of MRSA?

By not completing a full course of antibiotics, partially resistant bacteria that slow their growth begin to multiply and a person becomes sick again. Upon taking the antibiotic again and the partially resistant bacteria slows its growth a second time; however, another random mutation causes a fully resistant bacteria to start growing. These MRSA bacteria are not affected by the antibiotic at all.

5 A student claimed that artificial selection has interfered with nature. Provide two reasons to support their claim. Provide two reasons that disagree with their claim. Which view do you agree with?

Students’ answers will vary.

They may include such ideas as the following: the traits selected may not have been selected for within their natural environment, the selectively bred organisms may not be able to survive on their own in the wild, they may have bred together in the wild anyway, and the original population still exists and they can still interbreed.

Student book answers

2.8 Natural selection affects the frequency of alleles

Pages 60–61

Extend your understanding 2.8

1 How does sickle cell anaemia get its name?

Sickle cell anaemia gets its name from the crescent shape of red blood cells being the shape of a sickle in individuals with this genetic disease.

2 What are the symptoms of sickle cell anaemia?

Swelling of the hands and feet, fatigue and pain, strokes or damaging the joints and organs of the body

3 What does being a ‘carrier for sickle cell anaemia’ mean?

This means that heterozygous individuals have one normal haemoglobin allele and one sickle cell allele. These individuals produced both normal red blood cells and sickle cells. They get neither sickle cell anaemia nor malaria.

4 What is a selection pressure?

A selection pressure is an environmental factor that affects an organism's ability to survive.

5 How does malaria select for carriers of sickle cell anaemia?

A person who is a carrier for sickle cell anaemia is protected from contracting malaria (an infectious disease that is contracted through mosquito bites). People who are not carriers of the allele for sickle cell anaemia are at risk of catching malaria and dying. They are therefore selected against. Individuals who have two copies of the sickle cell allele have sickle cell disease and may die young. Therefore, carriers have a selective advantage in malaria-prone regions, survive at a greater rate than other individuals, and pass on this trait to their offspring.

6 Research the cause and symptoms of malaria. Why is resistance for malarial drugs increasing in some areas? Use natural selection to explain your answer.

Students’ answers will vary.

The following key points should be included:

• Cause – being bitten by a mosquito infected by the Plasmodium parasite that multiplies in the liver of the infected person; the parasite then matures in the bloodstream, where it infects and destroys red blood cells.

• Symptoms – fever, sweating, chills, shivering, headaches, breathing problems, vomiting, diarrhoea, swelling of the brain, coma and organ failure

• Resistance arises due to genetic mutations that give individual parasites reduced sensitivity to a particular malarial drug. Resistant parasites survive, reproduce and pass on this mutation, which passes on resistance to their offspring. They are selected for while non-resistant parasites are selected against. The drug becomes ineffective over time, and can no longer be used. A resistant parasite population has been established.

Student book answers

Review 2

Pages 62–63

Remember and understand

1 What is the difference between a hypothesis and a theory?

A theory is a hypothesis that has been verified by many separate and tested observations. A fact is an objective and verifiable observation. Therefore, a theory is based on a series of facts. For this reason, evolution will always be a theory because it is an explanation of observable facts.

2 What is natural selection and what are the four essential factors for this process?

Natural selection is the mechanism for evolution. The four key factors of natural selection are:

• not all individuals that are produced in a population survive to produce offspring

• variation between individuals exists in a population

• those individuals that are ‘fitter’ contribute more to the next generation

• differences between individuals in a population are inherited.

3 Explain the difference between incorrectly suggesting an organism has evolved as opposed to correctly suggesting that a population of organisms has evolved.

An organism may change during its lifetime (humans may change hair colour or skin colour); however, their offspring will remain unchanged. Evolution is a change in all members of a population over a period of time.

4 Define the term ‘gene pool’.

The gene pool is all the alleles for all the genes present in a population.

5 What is the professional title for a person who studies the fossil record and geological time periods?

Palaeontologist

6 Archaeopteryx had features of both birds and lizards. What term is applied to fossils that show the evolutionary progression between two very different forms?

Transition fossils

7 What is or was Gondwana?

Gondwana was the land mass formed when the first large land mass (Pangea) separated into two. The other was Laurasia. Gondwana was comprised of the continents of Australia, Africa and South America.

8 The layering of sedimentary rocks is useful in relative dating. What is the basic principle of comparative dating?

Comparative dating is a judgement that a fossil is older or younger than a previously found fossil. This is often done by determining how deep underground the fossil was found.

9 Distinguish between the terms ‘transitional fossil’ and ‘living fossil’.

A transitional fossil is a fossil that shows some characteristics of two species but is not extinct. A living fossil is a currently living species that has remained unchanged over much time.

10 Explain precisely how fossils provide evidence for evolution.

Fossils provide evidence of how organisms have changed over time. The fossils are found at various depths in the soil and, as you move up through the layers, the fossils gain more features of currently living organisms.

Apply

11 Use examples to illustrate the two critical deductions that Darwin made – the struggle for existence and the survival of the fittest.

Students’ answers will vary according to examples used. An example should cover:

• the struggle for existence – there is a struggle for individuals to find resources (such as competition, food, space and mates) within a population, and some individuals have a greater struggle than others

• survival of the fittest – those that have greater fitness (that is, better suited to the environmental selection pressures) have a greater chance of survival, enabling them to reproduce and pass on their beneficial characteristics to the next generation.

For example, tortoises on dry islands with food found at a height result in struggle for tortoises with domed shells and short necks to source food and survive. Individuals with curved shells and long necks have a survival advantage that confers greater fitness. These tortoises survive, reproduce and pass on these features to their offspring.

12 Callistemon (bottlebrushes) are unusual because their stems (branches) do not terminate in flowers. Instead, the stem keeps growing out past the old flower. Consequently, a mature plant may contain the ripe seeds of numerous years in its branches. How has this adaptive feature enabled Callistemon to exploit the current Australian environment?

This means the plant is able to survive long periods of drought and still have viable seeds that can be dispersed in optimal conditions when water is present, ensuring the seeds germinated and develop into plants.

13 Connect the terms ‘allopatric speciation’ and ‘gene flow’.

Gene flow is prevented when two populations of the same species are isolated. There is no breeding between members of the two different populations, resulting in allopatric speciation.

14 Suggest why a vestigial structure, once it has been reduced to a certain size, may not disappear altogether.

Vestigial organs are structures that were used by the organism’s ancestor but are no longer used now. Vestigial organs may decrease in size, but they remain because there is no selection disadvantage in having them.

Analyse and evaluate

15 The tortoises of the Galapagos Islands either have a domed shell and a short neck (on islands with significant rainfall) or a shell with the front flared up and a long neck (on islands that are more arid). The tortoises feed on prickly pear cactus. On islands with no tortoises, the prickly pear plant is low and spreading, but on islands with long-necked tortoises, the prickly pear plant is tall and has harder spines protecting it.

a Why might the tortoises have two very different phenotypes?

Tortoises with domed shells and short necks are able to feed on the abundant, low-spreading prickly pear plants. Tortoises with long necks and shells that are flared up feed on tall prickly pears with harder spines. Both phenotypes are suited to their environments.

b Would the tortoises that originally reached the islands be likely to resemble any of the tortoises that live there today?

The tortoises that originally reached the islands would have had slight variations on the phenotypes that exist today.

c Using the terms ‘variation’ and ‘survival of the fittest’, explain why the prickly pear plant is so different on islands with long-necked tortoises compared with those plants growing elsewhere.

Tortoises with long necks were able to eat more of the spreading prickly pear plants than the short-necked tortoises. The variation of prickly pear plants that were best able to survive were those that were taller with more prickles (they were the fittest for survival). As a result, the cacti that were best able to breed were the tall cacti and so this type of cactus became more common. This also meant that tortoises with longer necks became the fittest for survival in that environment and therefore became more common.

d What type of speciation is occurring on these islands?

Allopatric speciation

16 Only two species of native non-marine mammals (both bats) existed in New Zealand before the Polynesians introduced rats and dogs 1500 years ago. This unusually small number of mammal species, along with New Zealand’s separation from Gondwana 60–80 million years ago, has led many to speculate on which land mass mammals originally evolved. The earliest known mammal-like fossil remains are over 160 million years old. Considering this information, explain whether a Gondwanan origin for mammals is likely.

The earliest known mammalian fossil remains are over 160 million years old. Between 180 and 120 million years ago, Pangaea started to break apart; 120 million years ago Gondwana broke away, with New Zealand separating 60–80 million years ago. This means mammals started evolving from reptiles while all the land masses were still attached to each other. It has been suggested that placental mammals arose on Laurasia and spread to South America, Africa and India when those land masses made contact once again. This is significant because it is thought placental mammals out-competed all marsupials (except opossums).

17 How does the study of DNA sequences help in our understanding of evolution?

The more similar a DNA sequence is between two species, the less time has passed since the organisms had a common ancestor. The study of DNA sequences provides evidence for evolution.

Ethical behaviour

18 Through selective breeding, humans are able to make speciation occur. Discuss the various scenarios in which this has occurred in the past and may occur now and in the future. Provide three examples of human intervention being positive and three examples of detrimental intervention. Support your choices.

Students’ answers will vary.

Examples students may use include:

• new species of dogs as a result of breeding for certain features, such as longer body and shorter legs in dachshunds – this can be detrimental if the dog becomes too long to be able to support their body adequately and, as a result, has spinal problems

• new species of minx cats with no fur – these animals would not be able to survive without human help

• choosing a species of wheat that is better able to survive in drought conditions

• choosing a greater variety of flowers, such as blue roses.

Critical and creative thinking

19 Research the various explanations for changes in the natural world before evolutionary theories. Select one example and present your findings and analysis to the class in an appropriate and interesting format.

Students’ answers will vary.

20 The theories of Lamarck and Darwin are often compared and contrasted in the form of cartoon strips. Prepare a three-part cartoon strip for each theory that clearly identifies the similarities and differences between these theories.

Students’ answers will vary.

21 Present the strengths and weaknesses of the various forms of evidence that support evolution.

Ideas could include:

• fossils – many (but not all) transitional fossils have been found

• anatomical homology – many structures are conserved across species; some structures are a result of analogous features

• embryonic – not all of the original diagrams of embryos were accurate, but they do correspond with molecular studies

• biogeographical – many corresponding fossils and living creatures support the joining together of the land masses; like fossils, there are still some gaps

• molecular homology – important molecules show a strong conservation across species; some molecular studies indicate that some species are related to unexpected evolutionary branches.

22 To appreciate how different people can hold different views on the theory of evolution, select a team of three to role-play the following, presenting and defending a range of perspectives on the theory of evolution validated with evidence-based reasoning: An atheist who accepts the evidence of evolution, a creationist who does not accept the evidence of evolution and a person who accepts the evidence of evolution and maintains a religious faith of any denomination.

Student answers will vary.

Diversity and evolution

23 In what ways are the terms ‘diversity’ and ‘evolution’ linked? How does one rely upon the other? Can evolution occur without diversity? Can diversity occur without evolution?

Evolution, the changing of one population as a result of selection pressures, can cause new species to form. This results in the formation of a greater diversity of organisms, meaning that the diversity of species is dependent on evolution. Diversity within a species is another way of saying variation. It is the variation of a species that enables natural selection, and hence evolution, to occur. Therefore, evolution is reliant on the diversity within a species.

Research

24 Choose one of the following topics for a research project. Present your research in a format of your own choosing, giving careful consideration to the information you are presenting.

Darwin and the Galapagos Islands

Much of Darwin’s theory developed while he was visiting the Galapagos Islands. Which new species did he find there? What was so unique about these species? How did Darwin’s findings help him develop his ideas?

Modern-day evidence for evolution

There is evidence of current populations evolving by natural selection all around us. Research one of the following topics and see whether you can find evidence of evolution by natural selection occurring today.

– Can controlled breeding modify organisms?

– When fewer predators are present, how does brighter colouration evolve?

– How does natural selection lead to pesticide resistance?

Climate change and natural selection

How do you think climate change will affect species on Earth? Which species do you think will be most affected? Why is this? What could these species do to avoid becoming extinct as a result of changing habitats? How could they do this? Would all species be able to avoid the effects of climate change? Do you think new species may evolve as a result of climate change?

Real-time evolution

Significant advances in our understanding of evolution by natural selection have been vital to the study of diseases and pests. Antibiotic resistance in bacteria and the tolerance to herbicides in crops and pesticides in general agriculture are monitored closely. Why are these examples important? Why do they need close monitoring? Why do these organisms demonstrate evolution at such a fast rate?

Students’ answers will vary.