PEARSON science 10

Chapter 1: DNA and genetics

Unit 1.1

1 **D**eoxyribo**n**ucleic **a**cid

2 Nucleotides

3 Since 1869

4 A = adenine, T = thymine, C = cytosine, G = guanine

5 **a** Nitrogen-rich bases

b Sugar and phosphate molecules

c To the sugar molecule

6 The way that the nucleotides are organised creates two long strands of sugar and phosphate groups. These resemble the uprights of a ladder. The bases link the two strands, resembling the rungs of the ladder. The complete structure is then twisted into a double helix.

7 DNA is found in the nuclei of cells.

8 DNA is the molecule that determines the genetic characteristics of most living things. Chromosomes are made of DNA and protein. Genes are sections of chromosomes.

9 Due to their chemical characteristics, the bases can pair in only one way to form the ‘rungs’ of the DNA ‘ladder’. Adenine only pairs with thymine; cytosine only pairs with guanine.

10 The order of the bases along its length.

11 **a** Johannes Friedrich Miescher; Phoebus Levene; Oswald Avery; Erwin Chargaff; Rosalind Franklin; Maurice Wilkins; James Watson; Francis Crick

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b Johannes Friedrich Miescher isolated DNA for the first time.

Phoebus Levene identified the components of DNA and the arrangement of the sugar, phosphate and base in a nucleotide.

Oswald Avery showed that DNA holds the genetic code.

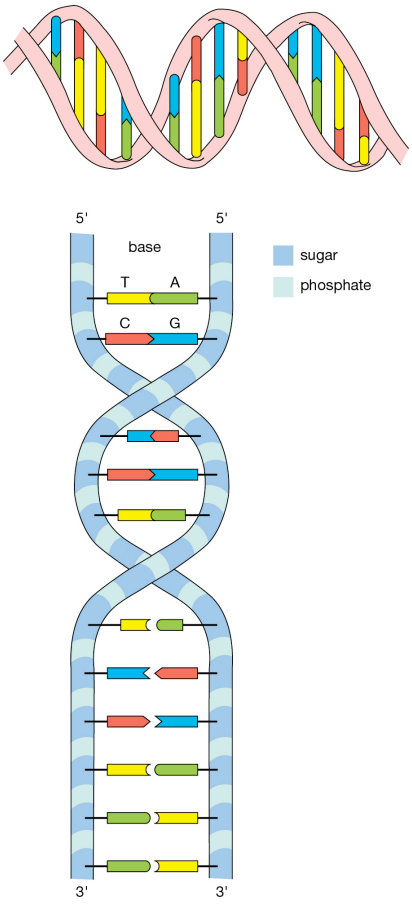
Erwin Chargaff discovered that:

- nucleotides are not arranged in the same order in all species
- in all species, the amounts of adenine and thymine in the DNA are always similar, as are the amounts of guanine and cytosine. This became known as Chargaff's rule.
- the amount of adenine plus guanine is always equal to the amount of thymine plus cytosine.

Rosalind Franklin and Maurice Wilkins used X-ray crystallography to create an X-ray crystallograph of DNA.

James Watson and Francis Crick worked out the double helix structure of DNA.

12 a Diagrammatic answer (see below)



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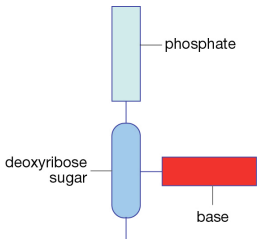
b Diagrammatic answer (see below)



13 **a** The seventh base pair is GG and should be GC or CG.

b The tenth base pair is TC and should be TA or GC.

c The fifth base pair is AA and should be AT and the eleventh base pair is AC and should be AT or GC.

14 There would be less genetic information (fewer genes) in the shorter chromosome.

15 A gene is a section of DNA that codes for a particular characteristic. It is a part of a chromosome.

16 The DNA would have the same basic structure in all these organisms. The nucleotides comprise phosphate, sugar and base; the bases are adenine, thymine, cytosine and guanine; and the method of complementary base pairing is the same.

17 **a** TACGAATCCAT

b AGCTGGCACCG

Unit 1.2

1 Mitosis

2 **a** Chromatid

b Replication

3 Meiosis

4 Replication creates two sets of chromosomes. When cell division occurs, a complete set of chromosomes is available for each of the new cells. In this way the genetic information of the individual remains intact.

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5 The haploid number is half the number of chromosomes in each cell of the body. It is described as one set of chromosomes and comprises one chromosome from each of the homologous pairs.

6 **a** Meiosis and mitosis

b Meiosis is the type of cell division that creates the gametes that join at fertilisation. Mitosis is the type of cell division that occurs as the puppy grows.

7 The fibres attach to the chromosomes during cell division. They pull the homologous pairs apart (in the first part of meiosis) or pull the chromatids apart (in mitosis or in the second part of meiosis).

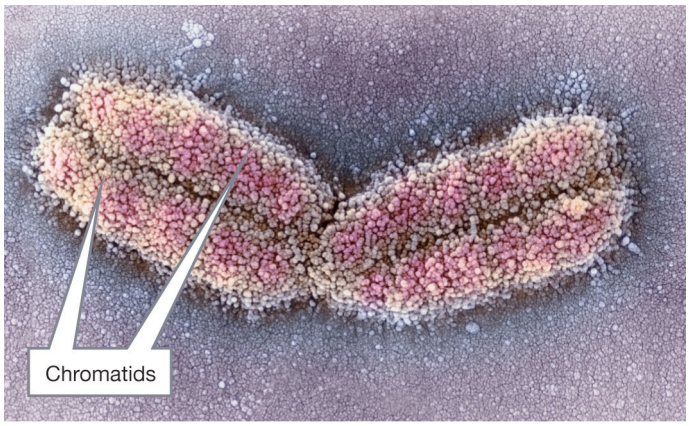
8 If the number of chromosomes was not reduced, each generation of a species would have twice the number of chromosomes of the parents.

9 The chromosomes replicate, creating exact copies of themselves. This is done in preparation for cell division.

10 32

11 24

12 Diagrammatic answer (see below)



13 The figure represents a chromosome that has replicated. It is two chromatids joined together.

14 Chromosomes A and E

15 Diploid cells have the 2N number of chromosomes. Haploid cells have the N number of chromosomes.

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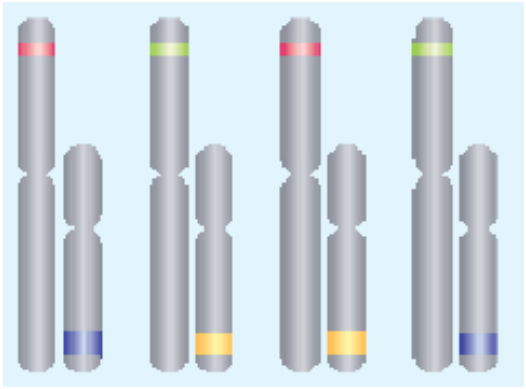
16 A chromosome is a double-stranded helix of DNA. When the molecule of DNA has replicated and two strands are joined together, each strand is known as a chromatid.

17



18 **a** The diagram drawn should show the phosphate–sugar backbone with the bases attached to the sugar in the order AGTGGCATCATTAAG. The other strand of the double helix should show the complementary bases in the order TCACCGTAGTAATTC.

b Justification should involve the concept of complementary base pairing.

Unit 1.3

1 A pure-breeding line of plants is one in which all individuals look the same and have the same genetic information in every generation.

2 **a** Allele phenotype **b** Heterozygote

c Phenotype **d** Homozygote

3 **a** 23 (N) **b** 46 (2N)

c 46 (2N) **d** 23 (N)

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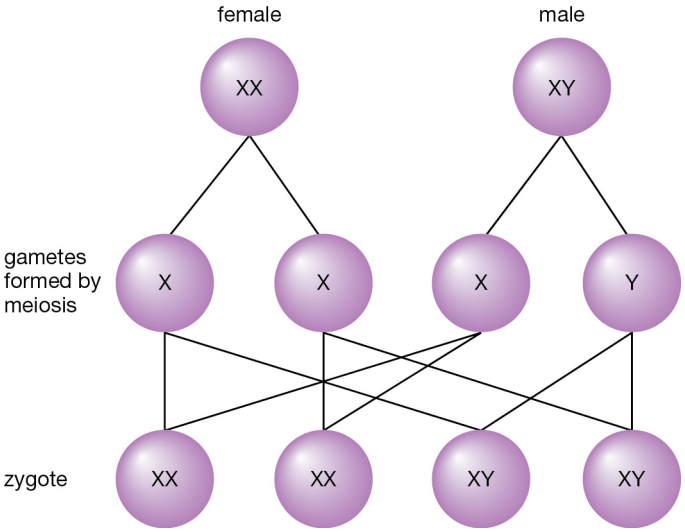
4 See Figure 1.3.7 on page 22 of the student book.



5 Sex-linkage involves characteristics that are inherited on the sex chromosomes. Many sex-linked characteristics are found on the X chromosome and not on the Y chromosome.

6 A gene controls a characteristic of an organism, such as petal colour or eye colour. Alleles are variations of the gene. One allele might cause the petals to be white and another allele could cause them to be red. One allele might determine the characteristic 'blue eyes' and another allele the characteristic 'brown eyes'.

7 **a** iv **b** vi **c** v

d i **e** iii **f** ii

8 **a** Answers may vary. The dominant symbol should be a capital letter and the recessive symbol a lower-case letter.

b Diagrammatic answer (see below)

	B	b
b	Bb	bb
b	Bb	bb

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9 The father will be colour blind and the mother will be a carrier.

Diagrammatic answer (see below)

	X^N	X^n
X^n	X^NX^n	X^nX^n
Y	X^NY	X^nY

10 **a** Homozygous means having the same alleles of a gene on homologous chromosomes. Heterozygous means having different alleles for a gene.

b Phenotype is the appearance of the organism. Genotype is the genetic information within the organism.

c Sex chromosomes are chromosomes that determine the sex of the individual. In humans they are the X and Y chromosomes. Autosomes are chromosomes that are not sex chromosomes.

11 **a** Dominant/recessive

b 1 Rr : 1 rr, or ½ Rr : ½ rr

c 1 red : 1 white, ½ red : ½ white

12 **a** Both parents are probably homozygous (pure-breeding) for the dominant red allele.

b Both parents are heterozygous, so they pass on the recessive characteristic (short-stem) to about 25% of their offspring.

13 **a** Cross pure-breeding black coat mice with pure-breeding white coat mice

b If all the offspring are black, this suggests that black is dominant to white. If all the offspring are white, this suggests that white is dominant to black.

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14 Tabulated answer (see below)

	A	A
a	Aa	Aa
a	Aa	Aa

	A	a
A	AA	Aa
a	Aa	aa

15 Student response.

Unit 1.4

1 One of the following: cotton, canola, carnations

2 Plasmid

3 13 years

4 Answers will vary. Example:

- To find out if an individual has the genetic characteristic for a particular disease.
- To clarify diagnosis of disease in an individual who is showing symptoms.
- To screen for diseases that are manageable with treatment or lifestyle changes, but that may cause significant problems if left untreated.

5 Replacement of defective genes in an organism with normal genes.

6 Recombinant DNA is DNA that has been recombined with other genes.

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7 **a** GM rice produces beta-carotene, the chemical that the body converts into vitamin A. Adequate vitamin A can prevent forms of childhood blindness.

b GM canola is resistant to the herbicides used to control weeds. The canola crop can be sprayed with herbicides to control the weeds without affecting the crop. This reduces production costs.

8 **a** The difference of one nucleotide base between one individual and another

b Through mutation

c Mutations can cause changes to proteins that may affect the normal function of an individual.

9 Four from the following:

- The introduced gene must be able to function in the target cells.
- The virus or liposome carrying the new gene may not reach every cell of the tissue. Rapidly dividing cells increase the number of cells that lack the gene.
- The body's immune system may destroy the vector and the gene.
- The virus used in the gene therapy may recover its pathogenic capabilities.
- Many diseases are caused by multiple genes.

10 **a** Ann and Harry are most closely related.

b The profiles for Ann and Harry have the most DNA markers in common.

11 Answers will vary. Example:

There is still a lot of research to do. For example, about 50% of DNA is repeat sequences of bases with no apparent function. However, they may cause changes in DNA that increase variation between individuals.

12 Answers will vary. Example:

Type 2 diabetes is a disease that may be preventable with changes to diet and lifestyle. People who know they have the characteristic could make changes that may prevent the disease. Huntington's disease is not preventable, and a person with the dominant allele will develop the disease. It cannot be prevented.

13 Decreasing blood flow to a tumour would reduce the oxygen and nutrients available for growth, slowing the tumour's progress and allowing other treatments to be more successful.

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14 DNA can be extracted from the skeleton of the deceased soldier and compared with the relative's DNA. There will be characteristics in the DNA that show that the two people are related.

15 The model should resemble the diagram in Figure 1.4.3, page 27 of the student book.

Chapter review

1 Adenine, cytosine, guanine, thymine

2 Deoxyribose

3 **a** Gene splicing

b Gene therapy

c Back crossing

4 Of the 46 chromosomes, half come from each parent. The autosomes in the set from one parent each have a homologue in the set from the other parent. These homologous chromosomes behave as pairs during meiosis. In the male, the sex chromosomes are not a homologous pair but they behave as such during meiosis.

5 Genes have different lengths and base sequences and they code for different proteins.

6 TACAAGGTCGCTTTAC

7 Each generation would double the number of chromosomes in the cells.

8 iPSCs appear to behave in exactly the same way as embryonic stem cells. Scientists believe these cells may have the potential to produce replacement parts of cells or organs damaged by disease. For example, they could replace neurones damaged by Parkinson's disease and multiple sclerosis, or cardiac muscle damaged by heart attack. There would be no problems with rejection of the replacement tissue because it would be made using the patient's own cells.

9 A—phosphate, B—base, C—sugar

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10 Cytosine and guanine are complementary bases, so the number of guanine molecules will be the same as the number of cytosine molecules.

11 The two parents could be homozygous for different alleles of a gene.

12 Genome—the genetic information carried by a haploid set of chromosomes.

Meiosis—the type of cell division that produces gametes with half the number of chromosomes of the parent cell.

Autosomes—the chromosomes that are not sex chromosomes.

Plasmid—circle of DNA found in bacteria.

13 When an organism is producing new cells for growth and repair, it is important that all the genetic information is copied so that all the cells have the same information. This is what happens in mitosis.

To ensure that each generation of the species has the same number of chromosomes, the number of chromosomes in the sex cells must be halved so that the full number is restored by fertilisation. This is why meiosis is required.

14 Haploid cells are sex cells. They have half the number of chromosomes of diploid cells.

15 Both types of stem cells are able to differentiate into a number of other cell types. Embryonic stem cells are able to become any type of cell found in the body. Adult stem cells are limited in the types of cells they can become.

16 The body cells of mules and hinnies would have 63 chromosomes: 31 from the horse and 32 from the donkey. If the cells underwent meiosis to produce gametes, the chromosomes from the different parents would not necessarily be homologous and one chromosome would not have a pair. In this situation, meiosis does not occur and gametes are not produced.

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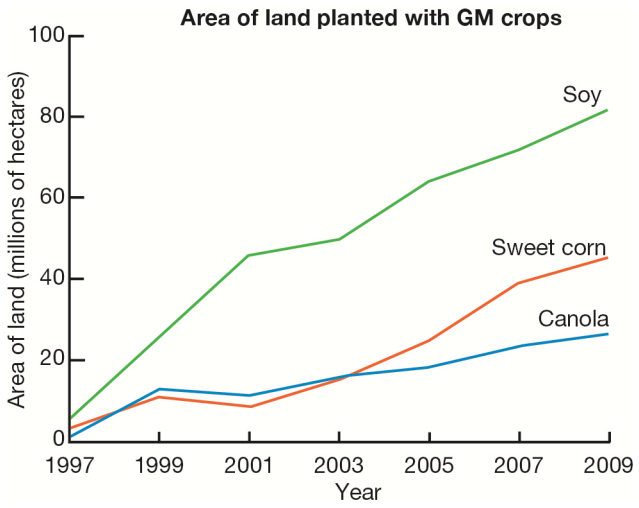
17 a Diagrammatic answer (see below)



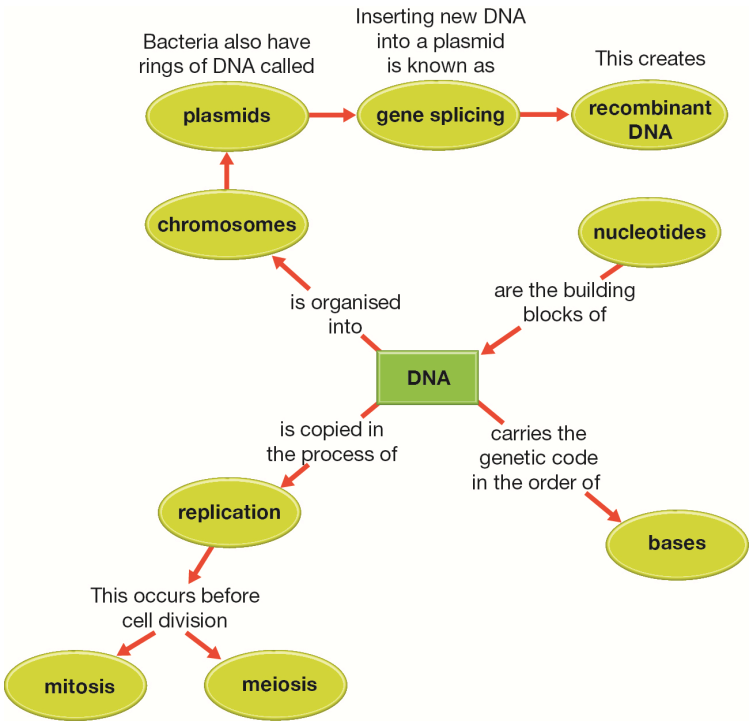
b i Canola had the largest percentage increase. It increased by 1650% compared to sweet corn (1500%) and soy (1640%).

ii The years 1997 to 1999 showed the greatest increase in the planting of canola.

iii The years 2001 to 2003 showed the smallest increase in the planting of soy.

c Soy

18 Diagrammatic answer (see below)



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Thinking scientifically

Q1 C

Q2 B

Q3 D

Q4 B

Q5 B

Q6 C

Q7 C

Q8 C

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Chapter 2: Geological time

Unit 2.1

1 Original—shell of clam. Replacement—opalised bones, petrified wood. Carbon trace—plant leaves. Mould—footprint. Cast—mould of shell fills with mud, mould decomposes leaving the cast

2 Palaeontologists study life from the past.

3 Reg Sprigg discovered what is believed to be the earliest group of multicellular organisms.

4 Fossils are the preserved evidence in rocks or soils of dead organisms.

5 Permafrost is temporarily frozen ground. Peat is partially decayed plants that are low in oxygen and are acidic.

6 Lack of oxygen and bacteria. Acid environments preserve soft tissue, alkaline environments preserve hard bone.

7 Dead organisms that lived in water or areas where sediments settle will quickly be covered by sediment and thus not be scavenged or decay rapidly.

8 Tollund Man was found in peat, which has little oxygen and is acidic. This stops decay by bacteria. Mammoths don't decay much as bacteria cannot grow when frozen

9 A replacement fossil forms by part of the organism being chemically changed into another mineral. Shells and bony skeletons often contain calcium carbonate, which can be replaced by a mineral such as silica (SiO_2).

10 Organisms are more likely to be fossilised in water because sediments are more common in water.

11 The Ediacaran fossils are the earliest group of multicellular organisms and are ancestors of all the life that followed them in the fossil record.

12 Worm burrows are fossils because they are traces of organisms that lived in the past.

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13 The moulds will be an imprint in the rock of the outside of an organism, and will be a depression (cavity) in the rock. The casts will not be an imprint in the rock, but a positive image looking like the organism.

14 Peat preserves soft tissues very well, but often bones lose their hardness. In tar pits, the bone remains hard, but soft tissue is often not preserved.

15 **a** Both carbon film and replacement fossils are slow processes where the fossil changes to material different from the original chemicals in the body. The carbon film is formed when all the material except carbon is lost. The replacement fossil results when one mineral is exchanged for another.

b The carbon film fossils will be black and powdery. The replacement fossils will be hard, solid rock and would usually not be a black colour.

16 If the bone has turned into silica-like opal. This is a replacement fossil, which is an extremely slow process taking many millions of years.

17 **i** Swamp plant—covered by sediment in water

ii Cat—bones preserved

iii Water bird—covered by sediment in water

iv Clam—hard shell preserved

v Frog—covered by sediment in water

vi Whale—covered by sediment in water

18 Calcium carbonate dissolves faster at higher pressures, so the deeper you go, the less likely solid calcium carbonate will remain. So a thick deposit of calcium carbonate probably formed in the shallows where the water pressure is lower.

19 Student answer.

20 Student answer.

Unit 2.2

1 Stratigraphy/index fossils, fluorine dating

2 Trilobites, ammonites

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3 Any three of:

- fairly widespread
- lived in a fairly narrow period of time
- are abundant
- are easy to identify.

4 Radioactivity, tree rings

5 Time taken for half the sample to decay.

6 **a** Relative dating is a technique in which the age of one fossil or rock is compared with another to determine which is older.

b Stratigraphy is comparing strata in different locations to determine their relative ages. You can use index fossils.

c Absolute dating techniques give an actual age for a fossil.

7 The lower strata are laid down first because sediments settle to the bottom. So fossils covered by these sediments are older than fossils found in higher layers.

8 A particular trilobite can be used as an index fossil. If it only lived at a particular time in the past, then rocks containing it should be about the same age. Finding the trilobite in strata in two different countries means those strata must be the same age.

9 Fluorine analysis shows whether the amount of fluorine in one fossil from a site is the same as another from the same site. The level should be the same if they are from the same stratum in the same locality. If the fluorine levels are different, then the bones are not from the same layer and locality.

10 If the rate at which radioactive elements break apart (decay) is known, then scientists can estimate how long ago the rock was laid down.

11 *Ameura*, *Ditomopyge*

12 **a** Cambrian

b *Isotelus*, *Ceraurus*

c
- Widespread
- Abundant
- Existed in only a narrow period of time (500–506 million years ago)

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13 a If *Anomelocaris* lived for a comparatively short time, then it qualifies as an index fossil and is of similar age to fossils found at the other locations.

b *Emuella* is not a useful index fossil (except for sites at Emu Bay), because it has only been found at Emu Bay so far. So it was not widespread.

14 b Tree ring dating would not work on a replacement fossil because the wood would have been fossilised too long ago to have any records of living trees that were around at the time of the fossil. Radioactive dating could work on the petrified tree trunk if suitable elements are present in the fossil.

15 a Layers 1, 7 and 9 are the same age as each other. Layers 2 and 10 are the same as each other. Layers 6 and 8 are the same as each other.

b Layers that have the same fossils in them must be of the same age (if the fossils are useful index fossils).

c Oldest to youngest is 3, 2/10, 1/7/9, 6/8, 5, 4.

16 There are few human and bird fossils compared with trilobites. There would not be enough fossils to be able to use them to date strata found in different places.

17 a Fluorine analysis will show that the fluorine level was different in the two fossils.

b Radioactive dating using carbon since it is accurate for organic material of dates less than 50 000 years.

c Tree ring dating or radiocarbon dating.

d Radioactive dating using potassium–argon.

e Fluorine analysis will show different amounts of fluorine in the bones, whereas they should be the same.

f Use index fossils.

18 Different species will have different shapes and few fossils will have legs and antennae still attached.

19 The wood may have come from a climate different from the existing scales used in tree ring dating. You would need to know where the ship was built and compare it with tree rings from trees and timber from that region.

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20 a Depends on student answer. The material of the artefact will have to be durable, such as gold watches and jewellery, diamond rings, glass ornaments and ceramic objects.

b The key points that show that the artefacts meet the requirements of an index fossil are:

- have been fairly widespread in where it was used
- have been used for only a fairly narrow period of time in the past
- be abundant, meaning there were many of them
- be easy to identify.

Some examples are gold watches and jewellery, diamond rings, glass vases and ornaments, wall and floor tiles with patterns, clay bricks and tiles. If some plastics turn out to be very long lasting, then artefacts such as CDs may be useful.

Unit 2.3

1 Geological time scale

2 Periods

3 Difficulty of fossilising tiny, delicate creatures. No life existed at all at that time.

4 488 mya early fish, 416 mya amphibians, 315 mya reptiles, 190 mya mammals, 200 mya birds

5 Palaeontologists first identified the sequence of named groups of fossils they found in strata from oldest to youngest.

The next step was to date some rocks by absolute dating and then add these to the sequence of named geological eras and periods. The combined information became the geological time scale.

6 Stromatolites are circular rocky structures that grow as columns. They are made by cyanobacteria (blue-green bacteria).

7 Stromatolites are the most ancient evidence palaeontologists have of living organisms.

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8 The lobe-finned fish are the likely ancestors of the amphibians, the vertebrate group that made the move from the water to the land. This led to all the land vertebrates (tetrapods), including humans.

9 Birds share many features, such as feathers, with a small branch of the dinosaurs called theropods.

10 *Archaeopteryx* has only been found in a few places. It was not abundant and so would be useless as an index fossil because most palaeontologists would not be likely to find it in any strata.

11 *Archaeopteryx* had feathers and a wishbone in the chest. These are both important for flight in modern birds. However, *Archaeopteryx* had teeth, a long tail of bones and fingers at the tip of its front limbs. So this creature had features of both reptiles and birds.

12 Animals require food because they cannot make their own. All food chains start with plants, so animals cannot survive until plants are present.

13 Reptile eggs and skin were waterproof, so they would not dry out in air like amphibians do. This means they could live in drier places.

14 Student answer. It should stress the uniqueness of the stromatolites:

- They are amongst the earliest organisms on Earth.
- Living examples are found in only a few places.
- Western Australia has most of the sites.
- They help us understand how early life may have developed on Earth.

15 Student response.

Chapter review

1 Fish, amphibians, reptile, mammals, birds

2 **a** Multicellular organisms appear in fossil record.

b Fossils become abundant.

c Lobe finned fish and amphibians.

d Dinosaurs appear.

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e Reptiles dominate the land.

f Dinosaurs dominate the land.

g Flowering plants appear.

h Human-like creatures appear.

3 **a** Fossils are the preserved evidence in rocks or soils of organisms which once existed on Earth.

b Index fossils can be used to compare the ages of strata in different locations.

c Radioactive dating is a method using radioactive decay (where elements break down at a steady fixed rate) that can determine an exact age for a fossil or rock.

d The geological time scale is a time scale of life and geology in the past.

4 Original—body is preserved and retains most of its form and chemical composition

Replacement—chemical replaced slowly by other chemicals

Carbon trace—most chemicals lost and mostly carbon remains

Mould—imprint of outside of body in rock. Cast—mould of shell fills with mud and mould decomposes leaving the cast.

5
- The chances of being fossilised are fairly low for any organism; it has to be covered by sediments and survive being squashed by the pressure of rock above it.
- Organisms on land have less chance of being covered by sediment.
- Hard body parts are more likely to be preserved than soft ones—few soft-bodied organisms would ever be fossilised.

6 Absolute dating by radioactivity, or by comparing any fossils with index fossils.

7 Index fossils were used to construct a sequence of strata from the oldest to the youngest. Then absolute dating was used to date those strata.

8 Chemicals in solution surrounding the trilobite fossil slowly remove chemicals in the skeleton and replace them with others such as silica.

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9 Predict appearance using fossils and living relatives.

Compare with other dinosaurs or close relatives. Many bones are similar in all vertebrates. Bone size is also related to body mass and this can be deduced from other similar animals.

Marks left on the bones by muscle attachment indicate how large the muscles were and also where they were positioned. Living relatives can serve as a guide.

Skin is placed on the muscle masses and a texture and covering such as feathers or scaly skin being decided using any fossils or living relatives.

10 **a** Any preserved evidence of a once living thing is considered to be a fossil.

b Palaeontologists can interpret fossils to determine the appearance of an organism.

c There are many methods that can tell how long ago a particular fossil was formed.

d Each species only lived at a particular time during the history of the Earth.

e Each species is found only in particular places on Earth in the past.

f The fossil record will never be complete because not every species is likely to have become fossilised.

g Palaeontologists will never be able to have a complete knowledge of the history of life on Earth.

h The geological time scale is constantly changing as new discoveries are made.

11 Not all dinosaur species would have lived in places where they would quickly become covered in sediments after death and therefore fossilised. (Favourable places would have swamps, lots of wind – blown soil, no scavengers and volcanic eruptions.) Some dinosaurs may have lived in places where they were quickly eaten by scavengers or where they would decay due to warm temperatures and abundant moisture (e.g. in tropical rainforests). So many dinosaurs were probably not in environments that would cover them quickly in sediments.

Some rare dinosaurs would have been less likely to have become fossilised and found in exposed rock strata.

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12 Create a decimal scale on the vertical axis by dividing ½ (= 0.5) into 5 equal parts, enabling us to locate 0.1 on the vertical axis. On the horizontal axis, divide each division (1251 million years) into 5 equal parts (250 million years). Draw a horizontal line from 0.1 on the vertical axis to the curve. From this point draw a vertical line to the time axis, reading off the answer of approximately 4000 million years.

13 The birds and bats may breathe in the poisonous gas while flying over the swamp. They could die and fall in the water, sinking to the bottom. This will increase the chance they may be covered by sediment and fossilised.

14 Relative and absolute dating do not give the same information. Relative dating cannot give an actual age for a fossil, only says if it is older or younger than another fossil. Absolute dating does give an actual age for how old the fossil or rock is.

15 A mould is usually an imprint that shows the outside of the body of an organism. This is a 'negative' image.

A cast forms when an organism in rock decomposes and the space in the rock fills with soil and turns to rock. This leaves a copy of the outside of the organism in a solid piece of rock. This is a positive image, meaning what the organism looked like in life in three dimensions.

16 Marine worms and earthworms are soft-bodied organisms, which do not often fossilise. Bats and desert plants are in environments where they are not likely to be covered by sediments, which is essential for fossilisation.

17 Student answer.

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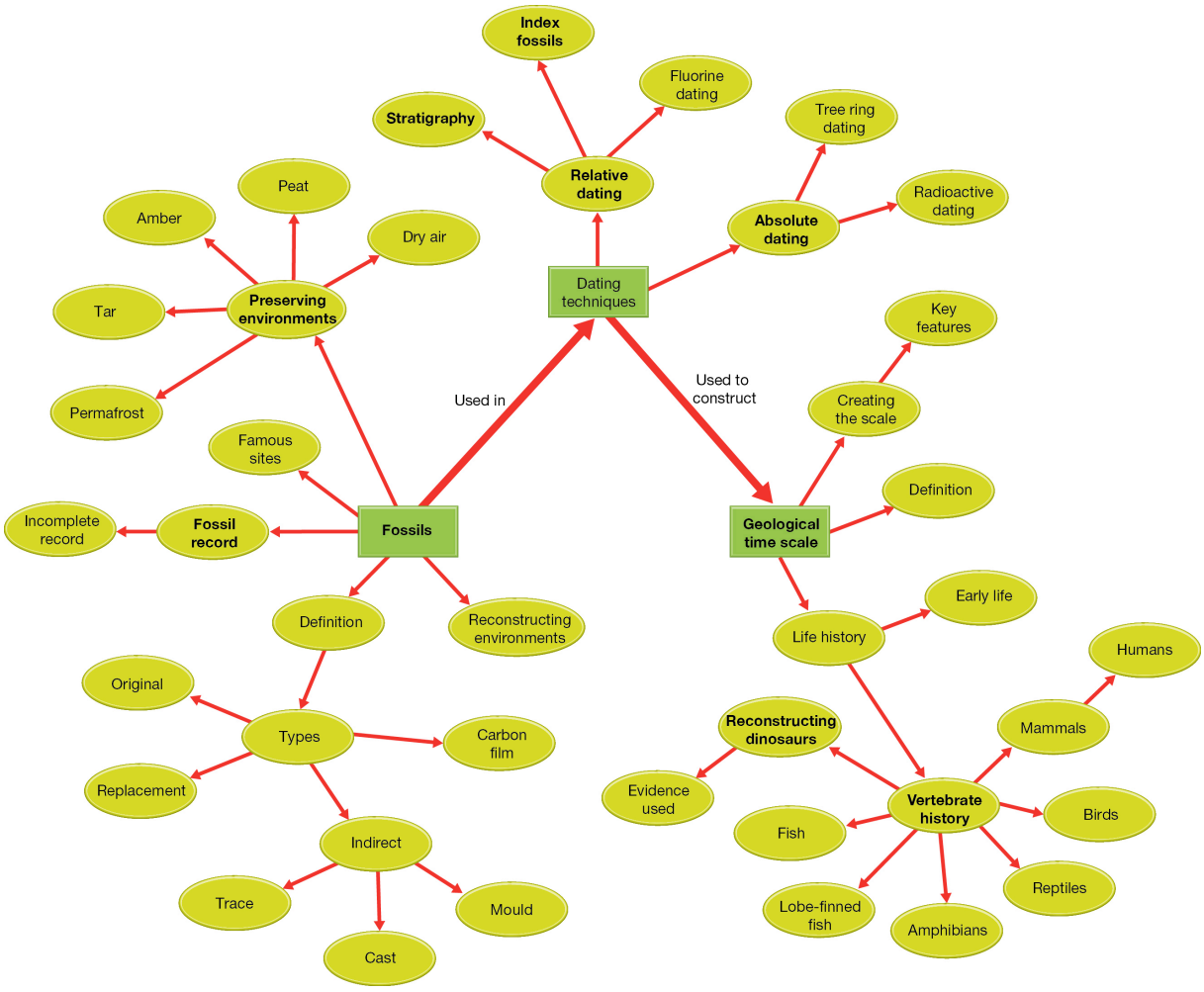
18 Diagrammatic answer (see below)



Thinking scientifically

Q1 B

Q2 C

Q3 A

Q4 B

Q5 D

Q6 C

Q7 C

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Chapter 3: Natural selection and evolution

Unit 3.1

1 Body increases in size, legs become longer and number of toes decreases.

2 Budgerigars—different colours and patterns. Dogs—different sizes and shapes

3 Birds seem to be related to a group of dinosaurs called theropods. They both have feathers.

4 **a** Genetic change in the characteristics of a species over many generations, resulting in a new species.

b The time between the birth of an individual and when they produce their own offspring.

c Structures that are controlled by some of the same inherited genes.

5 Fossils show the structure of past organisms; this can be compared with current living species. Many look similar and yet show some differences that suggest they changed over time.

6 Budgerigar breeders choose which parents will mate according to their characteristics. Mutations may be chosen and deliberately passed on. By continually selecting particular features, some of the general characteristics of the species such as size, colour and patterning can be changed.

7 Species with the same basic structure must have many genes the same because genes control structure and function in organisms. Therefore, species sharing genes must have had the same ancestor at some stage.

8 **a** Plants that were different from the normal plants—mutants

b Mutation

c He crossed parent plants with different features and selected offspring that had a combination of the desirable features.

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9 Dolphins and sharks both have a dorsal fin, and streamlined body shape. However, dolphins have lungs and shark have gills, so they are not very closely related.

10 **a** There are differences in the number of toes and the thickness of the toes. Toes changed from 4 to 1 and the central toe became thicker.

b The whole skull enlarges, the jaw grows relatively longer, a gap appears behind the front teeth and the teeth become longer.

11 Homologous structures look alike and have the same basic structure, such as the similar bone structure in the front limb of mammals, reptiles, birds and amphibians. Analogous structures may look alike, but they have a very different structure. For example, the fins on a shark do not have bones in them like the flippers on a dolphin.

12 The bat arm (wing) has most of the same bones as a mouse arm, and they are therefore homologous. But the long fingers of the bat support the membrane for the wing and are adapted for flying, whereas a mouse arm is for walking—two entirely different functions.

13 Cross-breeding is the process of producing offspring different from both parents, but with some desirable features from each. However, inbreeding is the crossing of parents who have similar features, the aim being to make the offspring as similar to the parents as possible.

14 Breeders waited for different features to appear in the offspring. These features were due to genetic changes. By taking these individuals and breeding from them the features can be passed on and become common and permanent in the offspring.

15 Birds are the only group of animals alive today that have feathers, and dinosaurs and birds are the only fossil groups known to have had feathers. Scientists say that feathers are homologous structures in birds and dinosaurs. This does not mean that feathers were used for the same purpose in dinosaurs and birds. Homologous structures occur through common genes.

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16 **a, b** Cross a dark-pink-flowered thorned rose with a white-flowered thornless one (i.e. cross-breed them). Plant the seeds and search among the offspring for any that may have inherited the pink flower and no thorns. Inbreed these, seek out the offspring with desired features and continue the inbreeding process for several generations.

Unit 3.2

1 Natural selection

2 Predation, bacterial infection, competition, temperature, water, soil nutrients, fire

3 Height, natural hair colour, length of legs, eye colour, ear lobe attachment are variations

4 **a** Natural selection is the process where an environmental factor acts on a population and results in some organisms having more offspring than others.

b A selective agent acts on a population and affects the chances of reproducing of some individuals more than others.

5 Natural selection is the change in proportion of a particular genotype of a species over many generations due to environmental selection of a particular phenotype (the phenotype is selected by the selective agent, not the genotype)

6 Differences in characteristics due to differences in genes.

7 The ability of organisms to survive insecticides or antibiotics due to inherited mechanisms such as being able to destroy the poison in their bodies.

8 Predatory birds could see the light-coloured moths more easily than the dark moths when the moths were on the blackened trees. So more light moths were removed from the population and the proportion of light offspring (i.e. the proportion of the light-coloured gene) was gradually falling. Eventually the population became mostly dark coloured.

9 Selection acts on differences—the selective agent is selecting one feature (phenotype) over another. If all individuals are the same, then none can be favoured by selection.

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10 **a** Insects—insecticides. Bacteria—antibiotics

b The ability to destroy the poison by the cell chemistry. Also, some bacteria have the ability to prevent the chemical entering the cell.

11 Both natural and artificial selection (directed selection) involve a factor in the organism's environment acting on the phenotype of the individual, and both change the number of offspring produced (usually by affecting their survival). However, artificial selection (directed selection) involves humans deliberately choosing which individuals will breed and then selecting which offspring will be allowed to breed.

12 Darwin thought about natural selection as something that could kill ('rejection of injurious variations'), whereas it is now thought of as a process where individuals are favoured in how many offspring they leave rather than whether they live or die. It often amounts to the same thing because an organism that lives longer usually also has more offspring.

13 Kettlewell concluded that the birds mostly ate the dark-coloured moths on the light tree trunks and light-coloured moths on dark tree trunks. The results support this.

14 On light-coloured soil, the population should have a much higher proportion of light-coloured mice than dark-coloured mice. The predators would see the dark mice more easily, and they would be preyed on at a greater rate, removing the dark gene faster than the light one.

15 Humans have been subjected to natural selection. An example is the Black Death in Europe in the 1600s. Many of the population died; those who survived had a higher inherited resistance to the bacteria. We are still subject to natural selection, but medicine has reduced the impact of this. Many survive now who would previously have died.

16 No. Adaptation occurs through natural selection, by change over generations.

17 **a** The pesticide

b No, it is natural selection.

c Although humans sprayed the chemicals, they did not deliberately choose particular insects to cross-breed.

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18 Depends on student answer.

19 This is not likely because the fetal head has to pass through the mother's pelvis during birth, unless reproduction occurs in a different way outside a mother's body. The mother's pelvis would have to be twice as wide as now for the same body height. This would probably interfere with walking.

Unit 3.3

1 Evolution

2 Interbreeding, protein structure, DNA sequence

3 Variation, isolation, selection

4 They don't recognise each other as the same species, they have different breeding times or breeding rituals, their gametes are incompatible

5 Part of the branchial arches in bird and fish embryos

6 See if two organisms can interbreed to produce fertile offspring under natural conditions. Identify the similarities in the amino acid arrangement in several different proteins they make. Determine the nucleotide sequence of the DNA (identify common genes).

7 Genetic isolation means different groups of the population must be prevented by some mechanism from interbreeding.

8 A donkey and a horse can mate and produce an offspring, but the mule offspring is always sterile.

9 Early fossils show fairly simple organisms; later ones show increasingly complex ones. This makes sense in the light of genetics, because new alleles and genes develop from existing genes by mutation. There is also an increasing number of species from the earliest fossils to the present day. This would be expected if species continually split into several other species over time.

10 If genes can flow freely, then any genetic difference such as a mutation can spread through a whole population. There will not be enough variation in the populations in the two different environments to allow natural selection to change them enough that they become reproductively isolated.

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11 The Gcm-2 gene controls how the branchial arches of the chicken embryo develop into parathyroid glands while the same arches in fish develop into gills. Since both are controlled by the Gcm-2 gene, then fish and chickens must be related. They have inherited the same gene, and genes are passed on from ancestors to offspring.

12 Islands are separated by water, which is an effective barrier to gene flow. Any changes due to natural selection in one place cannot reach the other population.

13 Fossils with features of two groups represent a group that is evolving, separating from ancestral groups. The lobe-finned fish would have included a species that evolved into amphibians. At some point, there must be species that had features of both groups as one evolves into another.

14 The process of speciation involving variation, isolation and selection results in the development of new, different species. This increases biodiversity.

15 a Evolution is the changes in the species over time, whereas natural selection is the process by which that happens.

b Speciation is the splitting of a species into two or more species whereas natural selection is the process by which that occurs.

c Evolution includes speciation. Evolution links all species by descent from a common ancestor; speciation is the process going on as new species develop from existing ones.

16 a Apes

b Apes have less difference in the protein—fewer mutations means shorter time span between groups.

17 The proposed evolutionary sequence (with amino acid differences with humans in brackets) is fish (21) $\rightarrow$ amphibians (18) $\rightarrow$ reptiles (15) $\rightarrow$ birds (13) $\rightarrow$ mammals.

The closest relative based on anatomy is chimps (0), then monkeys (1) and whales (10). So the number of amino acid differences is in the same sequence as the proposed evolutionary pathway.

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18 • One species with variation spreads over a wide area.

- A canyon deep and wide enough to be a geographical barrier develops.
- Selection occurs differently on each side of the canyon.
- Mutation and selection continues for a long time. Genetic isolation develops as changes in mating habits and body chemistry make them unable to breed even if the canyon disappears.

19 The diagram should show the following steps.

- Variation exists in the frog species.
- Nullarbor Plain develops—a climatic geographical barrier.
- Selection occurs differently in Western Australia and Victoria. Different selective agents operate.
- The frogs become genetically isolated as changes in mating habits, such as calls, and reproductive biology occur.

Unit 3.4

1 Class Mammalia, order Primates, family Hominidae, genus *Homo*, species *Homo sapiens*

2 Lemurs, lorises, tarsiers, Aye-aye, potto, New World monkeys, Old World monkeys, chimpanzees, gorilla, orang-utan, gibbons

3 Most of them have 'grasping' hands, nails rather than claws and forward-facing eyes.

4 Humans, chimpanzee, gorilla

5 Chimpanzee and gorilla

6 There were several types. *A. afarensis* was about 1.3 metres tall and weighed about 30 kg. Their brain was about 410 cm^3, about the size of a chimpanzee's, but they had a much smaller body weight. They walked upright on two legs as shown by the shape of their pelvis and the carrying angle of the femurs.

7 Modern humans evolved in East Africa about 200 000 years ago, migrated out of Africa 60 000 years ago and reached all continents by 15 000 years ago.

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8 mtDNA is only passed from mother to children. Mitochondria separate into each gamete while meiosis occurs.

9 My biological mother.

10 Perhaps *Homo erectus* migrated out of Africa and reached Flores some time in the past, where it evolved into a smaller species. Alternatively, *Homo sapiens* migrated out of Africa, became isolated on Flores and evolved into a smaller version of *Homo sapiens*. In either case, the brain size is very small relative to the body size of *H. floresiensis*.

11 *Homo ergaster* was about the same height as *Homo sapiens*. The Turkana Boy specimen was 1.6 metres tall and may have reached 1.85 metres as an adult. The Turkana Boy had a tall, slender body adapted for walking long distances, similar to ours. His brain size though was much smaller probably around 910 cm^3 when he reached adulthood compared with 1450 cm^3 for us.

12 Nuclear DNA comes from copies of the nuclear DNA received from both parents. mtDNA is inherited only from the mother as it is not nuclear DNA. The mtDNA in sperm is destroyed at fertilisation.

13 There is only one fossil, of a skull. Generalising from one skull needs to be done with caution.

14 Two independent methods of genetic analysis, mtDNA and Y chromosome analysis both show agreement on migrations from Africa—based on mutation rates in the two DNA types.

15 **a** *Homo ergaster* or *Homo habilis* migrated out of Africa before 1.7 million years ago.

b The Georgian specimen was very short—much shorter than *Homo ergaster*, but comparable with *Homo habilis*. Its brain was much closer in size to that of *Homo habilis* than *Homo ergaster*.

16 Upright stance evolved first as shown by *Australopithecines*, which were upright walkers long before there was any brain size increase.

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17 *Australopithecus afarensis* had a range of variation in brain size and this affected intelligence. The more intelligent, larger brained individuals had a greater survival rate because they could solve the problems of survival such as making better tools and finding better food sources. They therefore left more offspring who inherited their larger brain size and intelligence. The differences were eventually enough to classify them as *Homo habilis*.

Chapter review

1 Charles Darwin

2 Variation, isolation, selection, reproductive isolation/speciation

3 Fossils, comparative anatomy, DNA and protein sequences, distribution of species, embryology

4 **a** Homologous structures do not have to perform the same function in different species.

b Differences in the position of amino acids in a protein show how closely related species are.

c Organisms that look similar do not necessarily have the same genes causing the similarity.

d Variation in a species is not caused by natural selection.

e Natural selection acts on the phenotype of an organism.

5 Early fossils show fairly simple organisms; later ones show increasingly complex ones. There is also an increasing number of species from the earliest fossils to the present day. This is what you would expect if species continually split into several other species over time. Transitional forms are what you would expect if one group changes into another.

6 **a** Bacteria are resistant to antibiotics, insects are resistant to insecticides.

b Natural selection has resulted in improved survival and reproductive rates of individuals that have genes giving them resistance to the antibiotic or the insecticide.

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7 Using cross-breeding and inbreeding. Breeders choose which parents will mate. Mutations may be chosen and deliberately passed on. By continually selecting particular features, some of the general characteristics of the species such as size, colour and patterning, can be changed.

8 Speciation can only occur if groups are genetically isolated from each other. Then any change in one group cannot spread to the other group, which therefore allows enough differences to build up to make them different species.

9 Analysis of mutations in mtDNA and Y chromosomes have shown that particular mutations arose in Africa and in areas leading from Africa and around the globe in a steady time sequence.

10 Dark mice living on dark soil are camouflaged from predators by coat colour. If the climate becomes drier and predator numbers decrease, then lighter colours would enable mice to absorb less heat. Lighter colours would be selected for even on dark soil.

11 Birds (class Aves) did not exist before dinosaurs (class Reptilia). The fossil record shows that some species of dinosaur developed feathers and eventually one became different enough to be classified as a different class—birds.

12 Grasping hands, forward facing eyes and nails instead of claws.

13 The pentadactyl limb has changed from five digits supported by three major bones to the body into variations in the shape of the bones, number of digits and number of supporting bones. All changes are related to the function of the limbs in different species.

14 Without variation, neither can occur.

15 Homologous structures are those that in related individuals have the same basic structure. Analogous structures are ones that in distantly related individuals appear similar but have a different structure.

16 They are analogous structures.

17 Animals such as bacteria and insects have very short generation times, so natural selection acts on many more generations in the same time. This results in features being passed on to offspring much faster so the evolutionary change of adaptation will be much more rapid.

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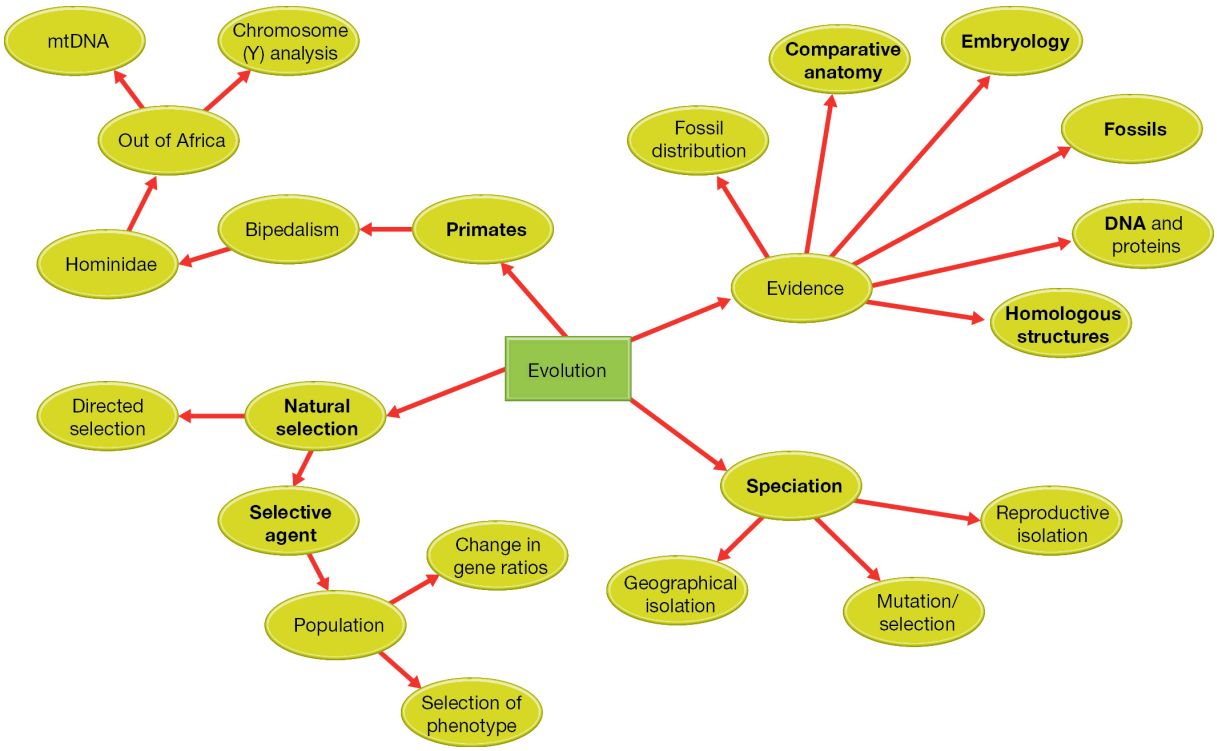
18 As long as the structure is based on homologous components (rather than superficial resemblance) then they must be related, because genes are what build structures and genes are copied from existing genes inherited from ancestors.

19 The structures associated with upright stance and walking—the pelvis, femur, foot and vertebral column structure.

20 Natural selection will remove any individual not adapted to cope with it. Domestic species are nurtured by humans and are not subject to most of the selective agents in the wild.

21 Early *Homo* had a range of variation in brain size and this affected intelligence. The more intelligent larger-brained individuals had a greater survival rate because they could solve the problems of survival. They therefore left more offspring who inherited their larger brain size and intelligence. Any mutations in genes affecting intelligence would have been selected for.

22 Diagrammatic answer (see below)



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Thinking scientifically

Q1 B

Q2 C

Q3 A

Q4 B

Q5 D

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Chapter 4: The periodic table

Unit 4.1

1 **a** Protons and neutrons

b Electrons

2 Electron, proton, neutron, atom

3 Atomic number = number of protons = 8

4 **a** O **b** Cl

c Mg **d** Fe

5 **a** Fluorine **b** Calcium

c Sodium **d** Lead

6 **a** Positive (+) **b** Negative (–)

c Neutral (0) **d** Positive (+)

e Neutral (0)

7 Number of electrons = $2n^2$. Hence shell 1 = 2 electrons, shell 2 = 8 electrons, shell 3 = 18 electrons, shell 4 = 32 electrons.

8 An electron configuration of 2,8,8 indicates that the atom has 2 + 8 + 8 = 18 electrons.

9 **a** Scanning tunnelling microscope

b Evidence obtained through deduction, not direct observation

c Number of protons in the nucleus of an atom

10 Proton and neutrons are roughly 1800 times heavier than electrons. The nucleus contains protons and neutrons and so most of an atom's mass lies in its nucleus. Outside the nucleus are the extremely light electrons.

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11 **a** Strong shadows, all in the one direction; shadows that gradually shift as the match progresses; change in light intensity as match progresses; spectators shielding their eyes from the Sun.

b Multiple shadows in different directions (one shadow per light tower); no change in shadows or light intensity as match progresses

12 50

13 **a** 2,1 **b** 2,4

c 2,8,1 **d** 2,8,7

14 **a** 1 × C + 4 × H

b 1 × H + 1 × N + 3 × O

c 6 × C + 12 × H + 6 × O

d 2 × C + 4 × H + 2 × O

15 Similarities:

- Both are located in the nucleus.
- Both have about the same mass.

Differences:

- The proton is positive while the neutron is neutral.
- The proton has a little less mass than the neutron.

16 The atomic number of carbon is 6 and for aluminium it is 13. Carbon is in period 2, group 14, while aluminium is in period 3, group 13. A carbon atom has 6 protons and 6 electrons in a configuration of 2,4 with only two shells being used. An aluminium atom has 13 protons and 13 electrons in a configuration of 2,8,3 using three shells. A carbon atom is lighter than an aluminium atom. Also, a carbon atom has fewer neutrons than an aluminium atom (extra information not described in text).

17 *Subatomic particle* implies that the particle is smaller than an atom. Hence, it describes protons, neutrons and electrons.

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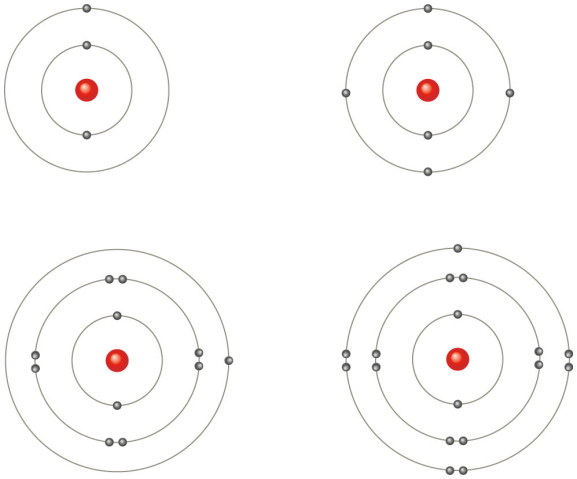
18 Diagrammatic answer (see below)



19 Student response.

Unit 4.2

1 **a** Nitrogen (N), phosphorus (P), arsenic (As), antinomy (Sb), bismuth (Bi), ununpentium (Uup)

b Lithium (Li), beryllium (Be), aluminium (Al), silicon (Si), phosphorus (P), sulphur (S), chlorine (Cl), argon (Ar)

c Any of the common transition elements, such as iron (Fe), gold (Au), silver (Ag), copper (Cu), zinc (Zn)

d Any of the lanthanides, such as cerium (Ce), praseodymium (Pr), neodymium (Nd), samarium (Sm), europium (Eu)

e Any of the actinides, such as uranium (U), plutonium (Pu), americium (Am), curium Cm), mendelevium (Md)

2 Chlorine, bromine and iodine; lithium, sodium and potassium; calcium, strontium and barium

3 **a** 31 (Lavoisier's original list of 33 included caloric and light)

b 36

c 55

d 60

e 118

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4 Eka-silicon

5 The number of occupied shells is the same as the period number. The number of electrons in the outermost occupied shell determines the group number.

6 The elements in each triad reacted in a similar way as if they were chemically related to each other.

7 To share the same box in the periodic table, atoms need to have the same atomic number. If they have the same atomic number, then the atoms belong to the same element, not different elements.

8 Mendeleev realised that some elements were not yet discovered and that gaps would need to be left for them.

9 **a** Period 2, group 13

b Period 3, group 17

c Period 4, group 2

d Period 4, group 16

e Period 5, group 2

10 **a** Boron (B)

b Chlorine (Cl)

c Calcium (Ca)

d Selenium (Se)

e Strontium (Sr)

11 **a** 2,8,4 **b** 2

c 2,5 **d** 2,8,2

12 **a** Period 2, group 18

b Period 3, group 3

c Period 2, group 15

13 **a** 2,6 **b** 2,8,8

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14 **a** 8 **b** 18

c 3 **d** 19

e 9 **f** 12

g 15 **h** 19

15 Similarities:

- All are in group 1.
- All have a single outer-shell electron.

Differences:

- All are in different periods
- All use different numbers of shells

16 Any of the following properties could be compared. Tabulated answer (see below)

Physical property	Eka-silicon: Mendeleev's predictions	Germanium: properties as measured
Colour	Grey	Grey
Atomic mass	72	72.61
Melting point (°C)	High	947
Chloride boiling point (°C)	Below 100	84
Density (g/cm^3)	5.5	5.35

17 Only 36 elements were known in Dalton's time so simple pictorial symbols could be given to each of them. Today 118 elements are known. It would be extremely difficult to devise 118 simple pictorial symbols for them. This complexity of symbols would lead to confusion when communicating with other scientists.

18 Dates that should be shown on diagram are:

1789: Lavoisier: classified elements as metals, non-metals and metalloids

1808: Dalton: gave all 36 known elements symbols

1829: Dobereiner: organised elements into triads

1864: Newlands: organised all 60 known elements according to atomic mass and in seven columns (law of octaves)

1869: Mendeleev and Meyer: organised elements into rows and columns according to atomic mass and chemical properties and relationships

1913: Moseley: organised elements according to atomic number

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Unit 4.3

1 **a** Metals have a low attraction for outer-shell electrons.

b Non-metals have a high attraction for outer-shell electrons.

2 **a** iii

b i

c ii

3 **a** ii

b iii

c i

4 Metal atoms lose electrons to form positive ions, which have more protons than electrons.

Non-metal atoms gain electrons to form negative ions, which have more electrons than protons.

5 **a** Sodium ion

b Chloride ion

c Oxide ion

6 Diamond and graphite

7 Monatomic means that atoms do not bond with others but instead stay by themselves.

8 The stability of noble gases comes from them having a filled outer shell or a stable eight electrons in their outer shell.

9 Metals are good electrical conductors because their outer-shell electrons are ‘free’, being part of an electron ‘sea’ and not being bound to any one atom. Hence, they can move to form an electric current through the metal.

10 **a** Malleable means that the substance can be bent and deformed without breaking. It is a property characteristic of metals.

b Ductile means that the substance can be drawn (stretched) into long, thin wires. It is a property characteristic of metals.

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11 The bonding takes place via three simple steps:

- Chlorine atoms rip the single outer-shell electron off nearby sodium atoms. This gives each atom the same electron configuration as that of a noble gas. It also gives the atoms a charge (sodium is now the sodium ion Na^+ and chlorine is now the chloride ion Cl^-).
- Electrostatic attraction between the oppositely charged ions pulls them together to form an ionic bond.
- This attraction is in all directions and so ions continue to bond to form a continuous lattice.

12 Molten and dissolved sodium chloride have free ions, while in solid sodium chloride the ions are not free.

13 Sodium chloride has charged ions (Na^+ and Cl^-) but they exist in equal numbers. Hence, the positive and negative charges balance each other, giving rise to no overall charge for the lattice.

14 Electrostatic attraction is three-dimensional and so an ion will attract oppositely charged ions in all directions. Hence, these ions will tend to cluster around each other. These ions will in turn attract more oppositely charged ions and so the lattice continues and does not break into small molecule-like groupings.

15 Being three-dimensional, metallic bonding 'shifts' with any shift of the atoms making up the metal. This shift in bonding keeps the atoms together regardless of how they are moved when the metal is bent. The 'free' outer-shell electrons are electrostatically attracted to the lattice of positive ions and move around them regardless of how the lattice is bent.

16 Each carbon atom is bonded to four other carbon atoms, forming a tetrahedral, pyramid-like structure. This number of bonds and the varying direction of the bonds make the structure extremely strong.

17 **a** Mg (2,8,2) loses 2 electrons hence charge is +2.

b Fluorine (2,7) gains 1 electron hence charge is –1 (or –).

c Lithium (2,1) loss 1 electron hence charge is +1 (or +).

d Phosphorus (2,8,5) gains 3 electrons hence charge is –3.

18 **a** Br (group 17) = –1 or –

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b Sr (group 2) = +2

c Se (group 16) = –2

d Fr (group 1) = +1 or +

19 Tabulated answer (see below)

Number of protons	Number of neutrons	Number of electrons	Overall charge	Atom or ion?	Symbol
8	6	10	–2	ion	O^{2-}
10	10	10	0	atom	Ne
13	15	10	+3	ion	Al^{3+}
17	18	18	–1 (or –)	ion	Cl^{-}
19	20	18	+1 (or +)	ion	K^{+}

20 The flow of electricity relies on charges (ions or electrons) being free to move. In an ionic substance, the charged particles are the ions. When solid, the ions are locked in their lattice. All they can do is vibrate. The ions cannot move through the lattice. Hence, ionic substances are electrical insulators when solid. When these substances are melted, the ions are freed. They can therefore move and carry an electric current.

21 **a** 2 **b** 3

c 1 **d** 4

22 **a** Lattice

b Atom

c Molecule

23 Similarities:

- Each molecule has two atoms of the same element in it (each molecule is diatomic).
- The atoms in each molecule are held together by covalent bonding.

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Differences:

- Each contains atoms of different elements.
- H_2 has a single bond formed by a single shared electron pair.
- O_2 has a double bond formed by two shared electron pairs.
- N_2 has a triple bond formed by three shared electron pairs.

24 **a** Not possible

b Likely (actually exists)

c Not possible

d Likely (actually exists)

e Not possible

25 Neutrons are neutral. Since they have no charge, they don't affect the charge of an ion.

Unit 4.4

1 **a** Group 1

b Group 2

c Group 17

d Group 18

2 **a** The smallest atom is the one with the least shells. Hence, lithium (Li).

b Reactivity of alkali metals increases as you move down the group. Hence, francium (Fr).

3 **a** Any other group 1 element, e.g. sodium (Na), lithium (Li).

b Any other group 2 element can be given, e.g. barium (Ba), magnesium (Mg).

c Any other group 16 element can be given, e.g. sulfur (S).

4 Amorphous carbon, diamond, graphite and buckyballs (a spherical arrangement of carbon atoms)

5 Fluorine F_2, chlorine Cl_2

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6 Distillation

7 Both helium and hydrogen are lighter than air and so can be used in airships. However, hydrogen is explosive and therefore dangerous. Helium is unreactive and safe.

8 Carbon is in group 14, so it can covalently bond with up to four other atoms, including other carbon atoms. This ability allows it to form chains of carbon with bonds to other elements.

9 Both oxygen and sulfur are in group 16 and so both atoms have 6 outer-shell electrons. Gaining two extra electrons gives these elements the electron configuration of a noble gas. Therefore, both will form two covalent bonds with other non-metals such as hydrogen. Hence they form similar molecules such as H_2O and H_2S.

10 **a** $2Na + 2H_2O \rightarrow 2NaOH + H_2$

b $2Rb + 2H_2O \rightarrow 2RbOH + H_2$

c $2Li + I_2 \rightarrow 2LiI$

d $2Na + Br_2 \rightarrow 2NaBr$

11 **a** S

b NaBr

c H_2O

12 The noble gases are all stable unreactive gases. Their atoms have filled outer-shells or have a stable eight electrons in the outer shell. While fluorine and chlorine are gases at room temperature, bromine is a liquid and iodine is a solid. All are reactive (fluorine extremely so) since they all have only seven electrons in their outer shell and so need one more for stability.

13 Similarities:

- All are solid metals.
- All are reactive.
- All form positive ions.

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Differences:

- Atoms of alkali metals have 1 electron in their outer-shells while atoms of alkaline earths have 2.
- Alkali metals form +1 ions while alkaline earths form +2 ions.
- Alkaline earths are not as reactive as alkali metals.

14 Helium has the lowest mass of all the noble gases and is the least dense. Hence, it would be the 'lightest', making it ideal for balloons.

15 While tin is acting as a metal, it is strong enough to hold its shape and is able to bend (it is malleable) if knocked. Hence, it can easily hold heating fuel. Below 13°C, it acts as a non-metal. Non-metals crumble easily and hence any container made of tin could easily crack or leak. This is most likely what happened.

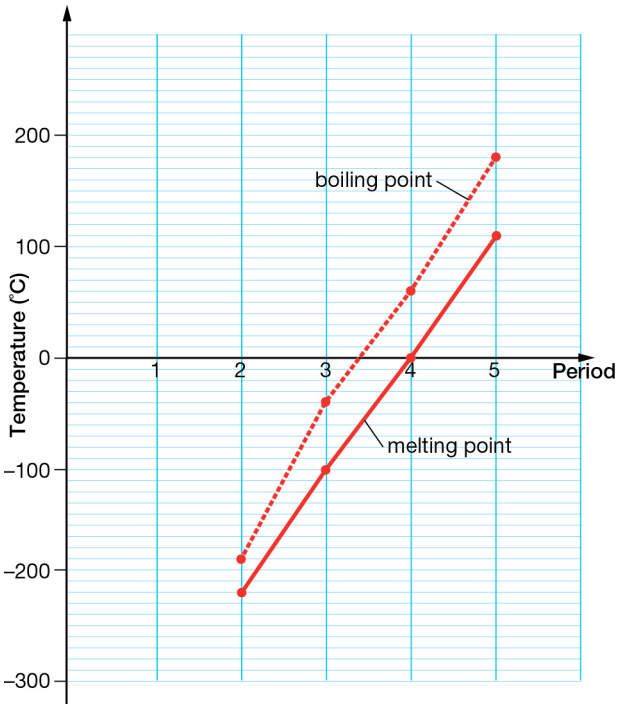
16 a i Solid = I, liquid = Br, gas = F, Cl

ii Solid = I, gas = F, Cl, Br

iii Solid = Cl, Br, I, liquid = F

iv Liquid = I, gas = F, Cl, Br

b Diagrammatic answer (see below)



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Chapter review

1 There are 118 different elements that are currently known.

2 **a** Fluorine

b Calcium

c Sodium

d Lead

3 **a** Sulfide ions

b Aluminium ions

c Phosphide ions

4 He, Ne, Ar, Kr, Xe, Rn (Uuo)

5 Group 1 = +1, group 2 = +2, group 13 = +3, group 14 = +4 or –4, group 15 = –3, group 16 = –2, group 17 = –1, group 18 = neutral (0)

6 Atoms contain positive protons and negative electrons in equal numbers. Hence the positive and negative charges balance, giving the atom an overall neutral or zero charge.

7 **a** Malleable means able to be bent.

b A lattice is a regular arrangement of particles (e.g. NaCl and diamond).

c An allotrope is a different physical form of a particular element (e.g. C).

d An organic molecule is a molecule with a backbone of carbon atoms.

8 **a** Helium could be placed in group 2 because it has two outer-shell electrons.

b Helium has a filled outer-shell, giving it properties more like the other group 18 elements than the group 2 elements.

9 A sodium atom has 11 electrons arranged in the electron configuration 2,8,1. It loses its outer-shell electron to a non-metal atom and then has one more proton than electron. This gives it a +1 charge and so it is an ion.

10 Atoms in the same group have the same number of electrons in their outer shells. Hence they form ions of the same charge and/or form the same number of covalent bonds. Hence, they form similar compounds in similar ways.

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11 a Mercury (Hg)

b Sodium (Na), magnesium (Mg), aluminium (Al)

c Tin (Sn), lead (Pb)

12 a Nitrogen (N), phosphorus (P)

b Carbon (C), nitrogen (N), oxygen (O), fluorine (F), neon (Ne)

c Fluorine (F), bromine (Br), iodine (I)

d Sulfur (S)

13 a Metallic

b Ionic

c Covalent

d Ionic

e Covalent

f Metallic

14 a –2

b +3

c +1 (or +)

d –3

15 a 3

b 2

c 4

d 1

16 a SiH_4

b GeH_4

c SnH_4

d PbH_4

17 a $Br_2 + H_2S \rightarrow S + 2HBr$

b $I_2 + H_2S \rightarrow S + 2HI$

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18 Ionic bonding involves the transfer of electrons from metal atoms to non-metal atoms while covalent bonding involves sharing electrons between non-metal atoms.

Ionic bonding causes the formation of lattices while covalent bonding usually causes the formation of molecules (except in the cases of diamond and graphite).

19 **a** Unlikely: being a group 17 element, Br^- is more likely.

b Likely: being a group 2 element, Sr^{2+} is likely.

c Unlikely: being a group 16 element, Se^{2-} is more likely.

d Unlikely: being a group 1 element, Fr would form the positive (not negative) ion Fr^+.

20 Lead has the symbol Pb (from the Latin *plumbum*). Plumbing originally involved lead pipes and so the person who worked with them and the pipes became known as a 'plumber' and 'plumbing'.

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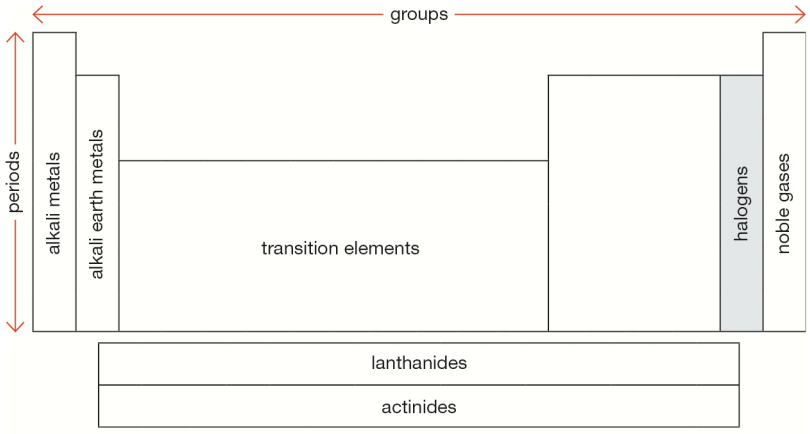
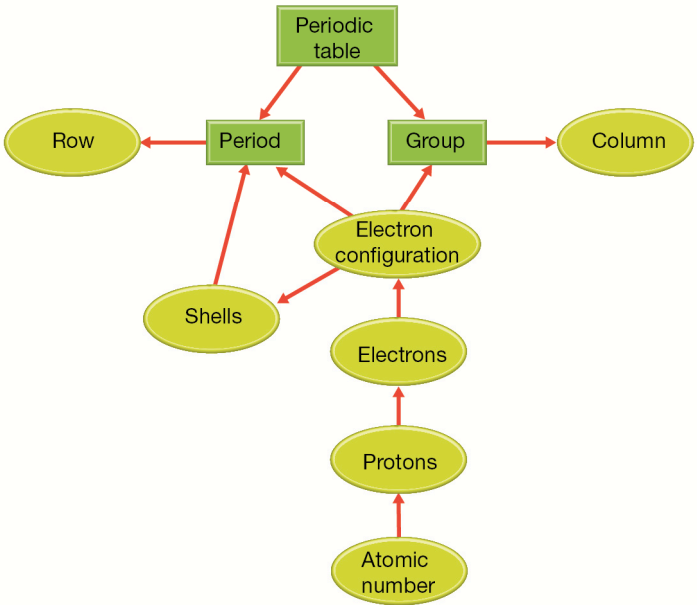
21, 22 Diagrammatic answer (see below)





Thinking scientifically

Q1 C

Q2 D

Q3 B

Q4 A

Q5 A

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Chapter 5: Chemical reactions

Unit 5.1

1 **a** Reactants

b Products

2 'Combine to give' or 'rearrange to give'

3 Atoms (or matter) cannot be created or destroyed during a chemical reaction.

4 (s) solid, (l) liquid, (g) gas, (aq) aqueous solution

5 During a chemical reaction, atoms cannot appear or disappear and so there should be the same number of each type of atom on both sides of the equation.

6 The 2 means that 2 methane (CH_4) molecules take part in the reaction. The 4 means that there are 4 hydrogen atoms in each methane molecule.

7 The symbol NaCl(s) indicates a solid, sodium chloride crystal lattice. The symbol NaCl(aq) indicates that the sodium chloride is dissolved in water.

8 **a, b** **i** copper(s) + nitric acid(aq) → copper nitrate(aq) + nitrogen monoxide(g) + water(l)

ii sulfuric acid(aq) + sodium carbonate(aq) → carbon dioxide(g) + water(l) + sodium sulfate(aq)

iii magnesium(s) + oxygen(g) → magnesium oxide(s)

iv sodium(s) + water(l) → sodium hydroxide(aq) + hydrogen(g)

9 **a** $CO_2(g)$

b $H_2SO_4(aq)$

c $H_2(g)$

d $K_2CO_3(s)$

e $HNO_3(aq)$

f Ca(s)

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10 D

11 **a** $P_4 + 5O_2 \rightarrow 2P_2O_5$

b $2KClO_3 \rightarrow 2KCl + 3O_2$

c $BaO + 2HNO_3 \rightarrow Ba(NO_3)_2 + H_2O$

d $2Pb3O_4 \rightarrow 6PbO + O_2$

e $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$

12 **a** Reactants: copper(II) nitrate

Products: nitrogen dioxide, oxygen gas, copper(II) oxide

b copper(II) nitrate $\rightarrow$ nitrogen dioxide + oxygen + copper(II) oxide

c $2Cu(NO_3)_2(s) \rightarrow 4NO_2(g) + O_2(g) + 2CuO(s)$

13 Some of the mass had been lost as the carbon dioxide gas escaped.

14 **a** magnesium + oxygen $\rightarrow$ magnesium oxide

b, c $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

d The total mass of the reactants is always exactly equal to the total mass of the products.

Unit 5.2

1 *Combination:* Hydrogen and chlorine reacting to produce hydrogen chloride. Magnesium and oxygen reacting to produce magnesium oxide

Decomposition: Hydrogen carbonate decomposing to form water and carbon dioxide. Sodium azide decomposing to form sodium metal and nitrogen gas

Precipitation: Scale or lime deposits. Kidney stones

Redox reaction: combustion and corrosion

2 **a** Gold, silver

b Iron, lead (also zinc, copper, mercury, nickel, tin)

c Sodium, potassium (also calcium, magnesium, aluminium)

3 Ammonium (NH_4^+) or hydrogen ion (H^+)

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4 May include: ammonium (NH_4^+), nitrate (NO_3^-), carbonate (CO_3^{2-}), hydroxide (OH^-), sulfate (SO_4^{2-}), phosphate (PO_3^{3-})

5 Soluble

6 **a** Rubidium bromide

b Potassium sulfide

c Beryllium oxide

d Sodium nitride

e Ammonium chloride

f Lithium hydroxide

g Silver carbonate

h Zinc sulfate

7 Oxygen gas is made up of molecules with two oxygen atoms. This needs to be specified so that the equation can be balanced properly.

8 Combination reactions combine several reactants into one product. Decomposition reactions form several products from one reactant.

9 Electrons from the electrode reduce the sodium ions to sodium atoms.

10 A solid will form, making the solution cloudy.

11 $2C(s) + O_2(g) \rightarrow 2CO(g)$ or $SiO_2 + CaO \rightarrow CaSiO_3$

12 $CaCl_2$: Calcium forms the calcium ion Ca^{2+}. Chlorine forms the chloride ion Cl^-. Therefore, you need to add 2 chloride ions to balance the positive charge on the calcium ion.

13 **a** Decomposition

b Combustion

c Combination and combustion

14 **a** $C(s) + O_2(g) \rightarrow CO_2(g)$

b $CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$

c $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$

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15 a magnesium + oxygen $\rightarrow$ magnesium oxide

b water $\rightarrow$ hydrogen + oxygen

c calcium oxide + water $\rightarrow$ calcium hydroxide

16 a Silver chloride

b Mercury(II) iodide

c Calcium carbonate

d Barium sulfate

17 a aluminium + oxygen $\rightarrow$ aluminium oxide

$4Al + 3O_2 \rightarrow 2Al_2O_3$

b magnesium + oxygen $\rightarrow$ magnesium oxide

$2Mg + O_2 \rightarrow 2MgO$

c magnesium + nickel ion $\rightarrow$ magnesium ion + nickel

$Mg + Ni^{2+} \rightarrow Mg^{2+} + Ni$

18 Combustion is used to help generate electricity, power vehicles, produce light and heat for warmth and to cook.

19 a N 2, H 8, S 1, O 4

b K 2, Cr 2, O 7

c Ca 1, O 2, H 2

20 Student response.

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21 Tabulated answer (see below)

Reaction type	Description	Example
Decomposition	A single reactant breaks apart to form several products.	$CaCO_3(s) \rightarrow CO_2(g) + CaO(s)$
Combination	Several reactants combine to produce a single product.	$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$
Precipitation	Two clear solutions mix and a solid is formed.	$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$
Combustion	A chemical reacts explosively with oxygen to produce heat and or light.	$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$
Corrosion	A metal reacts non-explosively with oxygen to form a metal oxide.	$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
Metal Displacement	A more reactive metal displaces the ions of a less reactive metal from solution.	$Mg(s) + Ni^{2+}(aq) \rightarrow Mg^{2+}(aq) + Ni(s)$
Carbon reduction	Carbon or carbon monoxide is used to reduce an oxidised metal back to its elemental state.	$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$
Electrolysis	An electrical current is used to force reactive metal ions to reduce to the metal atoms.	$2NaCl(l) \rightarrow 2Na(s) + Cl_2(g)$

Unit 5.3

1 Fast reactions: bullet firing, fireworks, burning gas stove

Slow reactions: wine fermenting, milk going sour, rusting

2 Temperature, concentration of reactants, surface area, agitation (stirring), catalyst

3 Catalyst

4 The rate of reaction is the speed at which a chemical reaction takes place.

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5 Increasing the temperature speeds up the chemical reaction that cooks the cake. If it is too low, then the cake won't cook. If it is too high, then the outside of the cake will cook before the middle and it might burn.

6 Continual stirring helps to flush away the products from around the reactants so that the reactants can continue to react quickly.

7 A catalyst offers a different pathway for the reaction to occur, which is faster or more likely. Some catalysts force reactants together so that they are more likely to collide and react.

8 The particles must collide so that the bonds holding the particles together can be broken and the atoms inside the particles can rearrange to form the products.

9 **a** Baking a cake by increasing the temperature, washing clothes by agitating the clothes in a washing machine

b Bread going stale by putting in an air tight container to reduce the concentration of oxygen, fruit rotting by putting in the fridge to reduce the temperature

10 Increasing the concentration of reactants

11 Taking more headache pills increases the concentration of the drugs in your system so it may work faster. However, because children are smaller, they need fewer tablets to achieve the same concentration.

12 A chemical change is when one or more substances are converted into different substances. A chemical reaction is the process that brings about a chemical change.

13 Heart rate is how fast your heart is beating. Interest rate is how fast your money earns interest.

14 In both cases, they maximise how much of a reactant is exposed to other reactants. In other words, they both make it easier for more reactants to react together at any one time.

15 **a** The fire will burn faster and produce more heat because you have increased the surface area of the wood.

b The fire will burn slower and produce less heat because you have reduced the concentration of oxygen which is also part of the chemical reaction.

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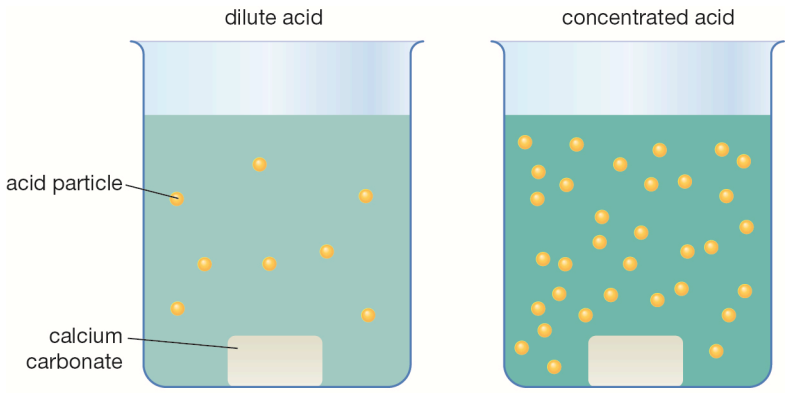
16 This increases the concentration of oxygen in the blood, which is important for respiration, the chemical reaction that produces energy for our bodies.

17



When the acid is concentrated, the acid particles collilde with the calcium carbonate block more often, giving them more chance to react. Therefore, the rate of reaction is faster.

Chapter review

1 Matter cannot be created or destroyed.

2 Decomposition, combination, precipitation, redox, combustion, corrosion, metal displacement, carbon reduction, oxidation, reduction, electrolysis

3 (s) solid, (l) liquid, (g) gas, (aq) aqueous solution

4 Carbon dioxide

5 Step 1: $2C(s) + O_2(g) \rightarrow 2CO(g)$

Step 2: $Fe2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$

6 Temperature, concentration of reactants, surface area of reactants, agitation, catalysts

7 The speed at which reactants are converted into products

8 Redox reactions are distinguished by the transfer of oxygen atoms from one substance to another or the transfer of electrons from one substance to another.

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9 *Nitrates* (no exceptions), all sodium compounds, all potassium compounds and all ammonium compounds.

Chlorides (except AgCl, $PbCl_2$, $HgCl_2$ and CuCl)

Sulfates (except $CaSO_4$, $SrSO_4$, $BaSO_4$, $PbSO_4$)

10 Rotting fruit by keeping the fruit refrigerated.

Rusting by coating iron with paint to reduce the concentration of oxygen at the surface.

11 When copper(II) carbonate ($CuCO_3$) is heated it decomposes to produce copper(II) oxide and carbon dioxide gas.

copper(II) carbonate $\rightarrow$ copper(II) oxide + carbon dioxide

$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$

12 **a** $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

b $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

c $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

d $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

e $2HNO_3(aq) + Ca(s) \rightarrow Ca(NO_3)_2(aq) + H_2(g)$

13 **a** Precipitation

b Decomposition

c Combustion

d Combination

14 **i** **a** sodium hydroxide + sulfuric acid $\rightarrow$ sodium sulfate + water

b $2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

ii **a** silver nitrate + sodium chloride $\rightarrow$ silver chloride + sodium nitrate

b $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

iii **a** hydrochloric acid + calcium $\rightarrow$ calcium chloride + hydrogen

b $2HCl(aq) + Ca(s) \rightarrow CaCl_2(aq) + H_2(g)$

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15 a Insoluble

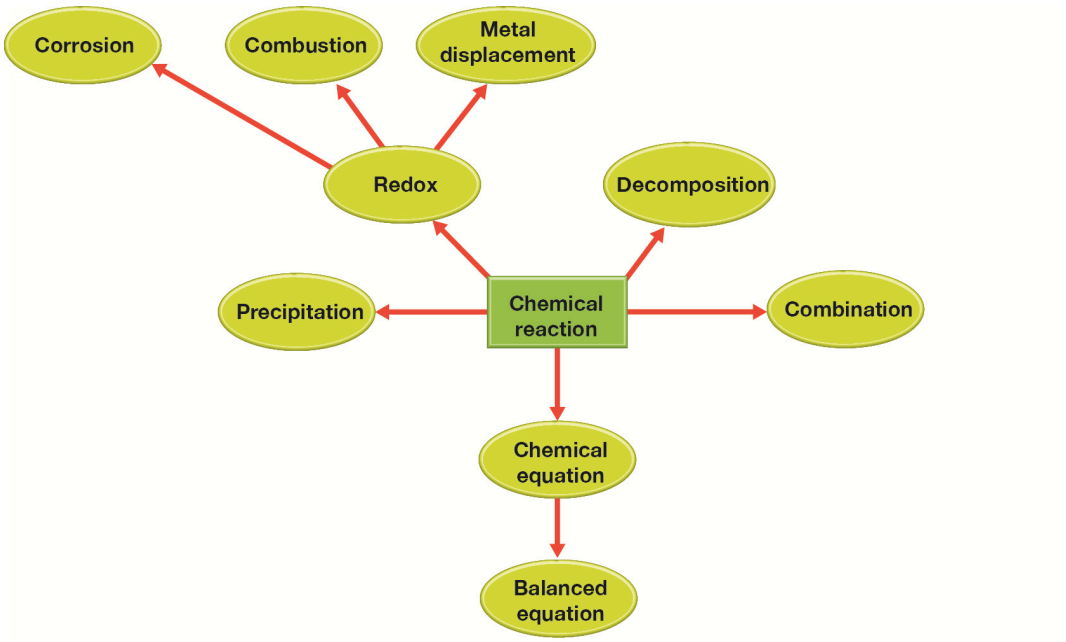
b Soluble

c Insoluble

d Soluble

16 The manganese dioxide is acting as a catalyst.

17 Diagrammatic answer (see below)



Thinking scientifically

Q1 C

Q2 D

Q3 D

Q4 A

Q5 D

Q6 D

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Chapter 6: Global systems

Unit 6.1

1 Photosynthesis

2 Respiration

3 Nitrates

4 **a** All parts of Earth's surface where living things exist. The sum of all ecosystems.

b Diverse ecosystems that provide for the needs of the organisms that live there.

5 **a** In photosynthesis, plants use carbon dioxide from the atmosphere to manufacture glucose. Consumers get carbon from the food they eat.

Consumer organisms get the carbon from the food they eat.

b Plants and animals use the glucose (containing carbon) and other elements to manufacture the proteins fats and carbohydrates that make up their bodies.

6 Wastes, including dead organisms, are used as food by decomposer organisms. As the decomposer organisms respire, carbon is released into the atmosphere, water and soil in the form of carbon dioxide.

7 Nitrogen-fixing bacteria convert nitrogen to ammonia and then to nitrates that plants can use.

8 Coal and oil are the fossilised remains of once-living things. The carbon in coal and oil came from the carbon-rich compounds that made up the bodies of those living things.

9 **a** Stores that are not available for recycling for hundreds, thousands or even millions of years.

b Coal and oil

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c They were both formed millions of years ago and the carbon they contain has not been available for cycling in all that time.

10 Most living things are not able to make use of nitrogen in the form of a gas.

11 All the elements used to make the tree have been cycled through the environment many times in the past.

12 Arrows of different thicknesses could represent the amount of carbon cycled. For example, reduced photosynthesis, increased burning of fossil fuels and human respiration, carbon entering the system in the form of food from another ecosystem.

13 Nitrogen-fixing bacteria make nitrates available to plants. Denitrifying bacteria make nitrogen unavailable to plants.

14 **a** The relationship is symbiotic.

b Both the plants and the bacteria gain from the relationship.

15 The lightning in thunderstorms converts nitrogen in the air to nitrates that dissolve in the rain and enter the soil with the rainwater.

16 The nitrates produced by *Rhizobium* are already within the plant and are available for use immediately. Nitrates in the soil have to be taken up by the plant roots before they become available. Only the nitrates within the range of the roots are available.

17 **a** Water will most likely be the result of water percolating through the soil and coming out at a lower level.

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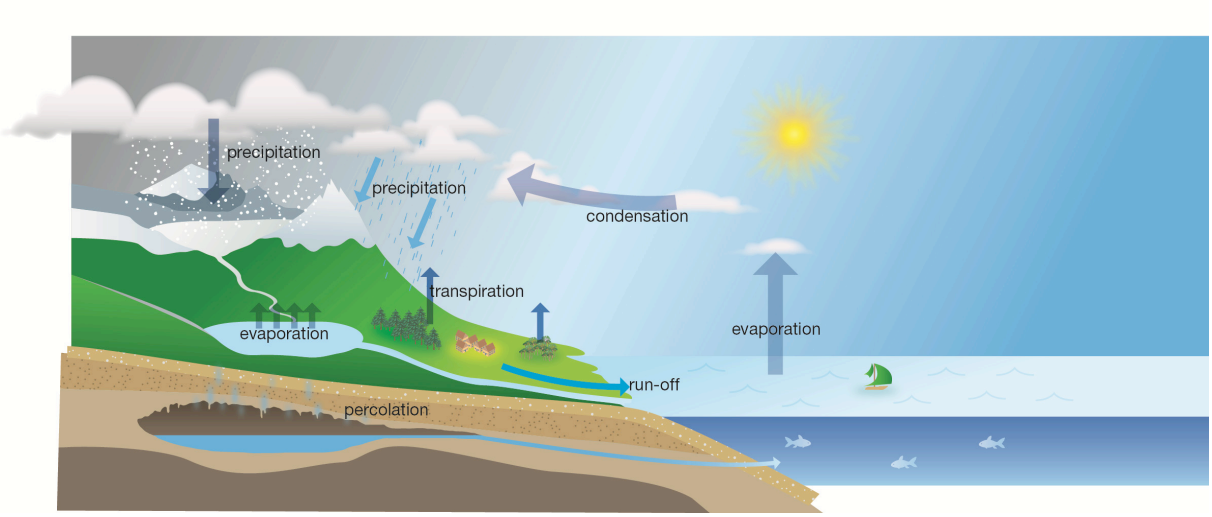
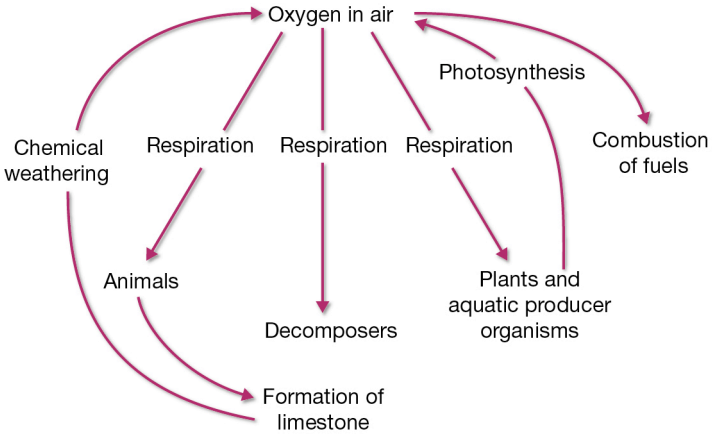
b Students could use a diagram similar to the lower part of the water cycle diagram in Figure 6.1.7 (see below).



18 Lupins, being leguminous, have root nodules containing nitrogen-fixing bacteria. By growing the crop then ploughing it in, the farmer is increasing the nitrogen content of the soil. The farmer will not need to use as much nitrogen-rich fertiliser on the subsequent crop.

19 Diagrammatic answer (see below)



Unit 6.2

1 About 1°C

2 Sun, the amount of cloud, amount of ice, forests, concentration of greenhouse gases in the atmosphere, tilt of the Earth's axis.

3 Water vapour, carbon dioxide, methane, nitrous oxide and ozone

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4 Wind, temperature, variations in salinity (salt levels), the rotation of Earth on its own axis, the gravitational pull of the Sun and Moon

5 **a** Wind

b Movement of very dense water

6 **a** False

b False

c False

7 **a** Periods between glaciations

b Interglacials are periods of global warming.

8 The Southern Oscillation Index (SOI) is a measure of the atmospheric and ocean conditions across the Pacific Ocean. Changes in the SOI give rise to both La Niña and El Niño events. When the SOI is positive there is a La Nina event in Australia. A negative SOI indicates an El Nino event.

9 Surface currents and deeper currents interact resulting in continuous movement of water around the globe. This resembles a conveyor belt that circles continuously.

10 As it moves around the globe relatively warm water is cooled. The heat is lost in a different part of the globe.

11 More of the Earth's water was frozen and trapped in the polar ice caps. Therefore the sea level was lower. The land between Australia and Papua New Guinea and mainland Australia and Tasmania was no longer under water.

12 Tahiti and Darwin are the places where the air pressure is measured in the calculation of the SOI.

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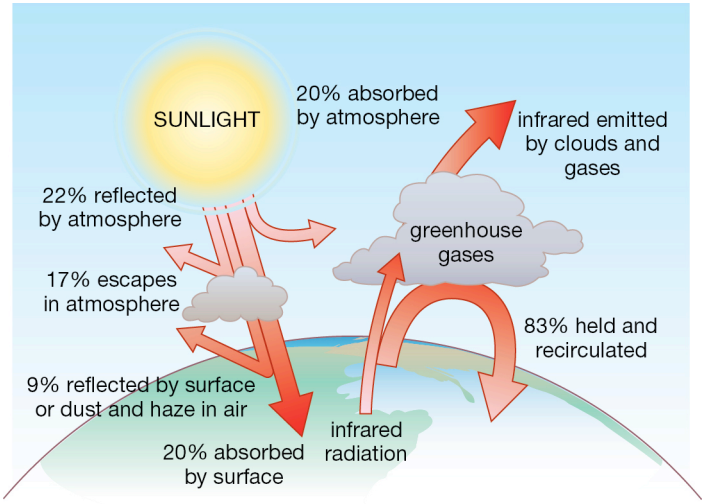
13 Diagram should be based on Figure 6.2.4 (see below)



14 a 3

b There are three times on the graph where there is a positive SOI. Weak in early 2004, and again in late 2005 early 2006. The SOI was strongly positive most of the time from late 2007 to early 2009. The lower positive values coincided with winter which is the traditional dry season.

c La Niña brings good rains to Queensland. In early 2009 the La Niña was still in place so it is likely that there were good rains in northern Queensland.

15 Under 'normal' conditions, the SOI is close to zero. During an El Niño event, the SOI is strongly positive. In 'normal' conditions there is a marked temperature and pressure difference between the western and eastern Pacific Oceans. During an El Niño event, there may be little or no difference in temperature and pressure between the western and eastern Pacific. In 'normal' conditions trade winds blow strongly from South America carrying moisture to the Australian coast. During an El Niño event the trade winds weaken and do not reach Australia.

16 a Late 2004; mid 2005; second half of 2006; mid 2008; mid 2009.

b These are times when the IOD was positive and a positive IOD suggests drier than normal periods.

c Wetter than normal conditions.

d During that time, the IOD was very strongly negative indication that there would be rainfall levels a lot higher than average.

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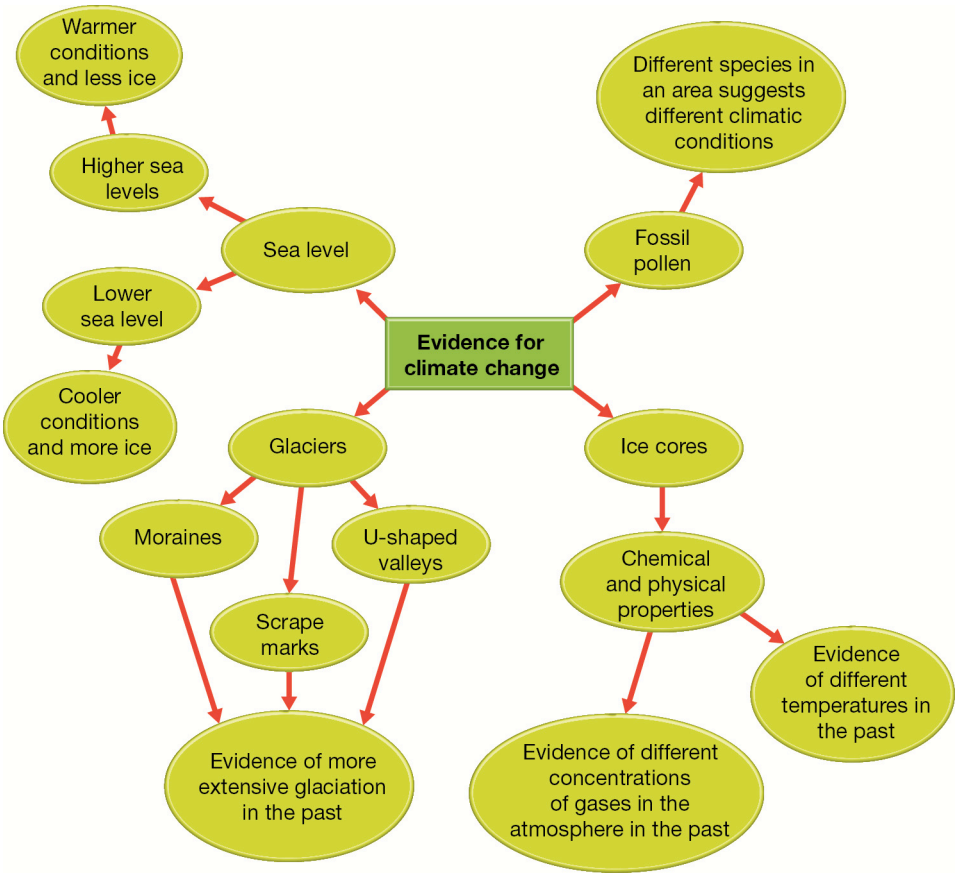
17 Without the greenhouse gases in the atmosphere, the Earth's average temperature would be around –18°C rather than 15°C. Different weather; different plants with adaptations to colder temperatures; greater difference between daytime and night-time temperatures.

18 a Sedimentary rocks are formed under water. Any sedimentary rocks that are above sea level must have been under water at some stage. The land may have risen due to seismic events but it is also possible that the sea levels have fallen.

b Sea levels are higher when the climate is warmer. The ice caps and glaciers melt, adding water to the oceans and the sea level rises.

19 Diagrammatic answer (see below)



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Unit 6.3

1 Increased use of fossil fuels, industrialisation, deforestation

2 Air temperature, ocean temperature

3 Thermohaline circulation

4 The ice is already in the oceans and displacing a large percentage of its volume. Also, ice has a larger volume than the equivalent amount of liquid water so as it melts, its volume will decrease. As a glacier melts, ice and water are being added to the oceans, thereby increasing the volume and water level.

5 Places and events that remove carbon dioxide from the atmosphere.

6 Nitrous oxide is produced through many industrial processes and the use of nitrogenous fertilisers. Industry increased in the early 20th century as did the use of nitrogen-rich fertilisers.

7 **a** The digestive systems of cattle and sheep, rice paddies, garbage tips, coal mines, natural gas fields and from the melting of permafrost

b Agriculture has increased the number of cattle and sheep, thereby increasing methane production. Cultivation of rice has increased. The number and size of garbage tips has increased. Mining for coal and development of gas fields has increased. If human activities are contributing to global warming, then humans can also be held responsible for the release of methane as the permafrost melts.

8 Carbon dioxide is an important greenhouse gas and scientific modelling of the enhanced greenhouse effect suggests that carbon dioxide is a major contributor to the effect.

9 Ice reflects more of the Sun's rays than dark surfaces such as forests and has a cooling effect on Earth. Reducing the area of ice would reduce this cooling effect.

Ice on water acts like a blanket, reducing the amount of heat that moves into the atmosphere. Less ice means more heat is added to the atmosphere.

As ice forms, the salinity and density of the water increases. The dense water sinks, becoming the driving force for the thermohaline circulation, which

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distributes heat around the globe, influencing the climate. Changing the amount of ice could change the thermohaline circulation and therefore influence climate.

10 a Australia 18.1 × 22.3 = 404 million tonnes

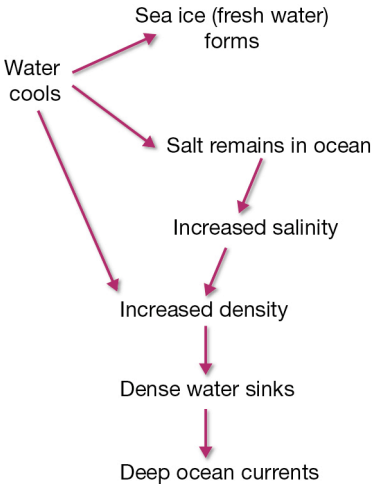
United States 19.5 × 307 = 5987 million tonnes

India 1.3 × 1140 = 1482 million tonnes

China 4.3 × 1325 = 5698 million tonnes

b US is the highest emitter, then China, India and Australia.

11 Diagrammatic answer (see below)



12 Global warming is an increase in the average world temperature. Climate change is the alteration of climates in various parts of the world caused by the global warming.

13 a Methane is 20 times more powerful as a greenhouse gas and nitrous oxide is 300 times more powerful than carbon dioxide.

b Carbon dioxide levels in the atmosphere are increasing at a faster rate than levels of other gases. Since the Industrial Revolution, carbon dioxide levels have increased from 20 ppm to 391 ppm, an increase of nearly 20 times. In the same time, methane levels have doubled and nitrous oxide levels have increased by 18% (about 0.2 times).

14 It means that data can be compared in a way that shows how individuals are contributing to CO_2 levels. Looking at the total CO_2 produced in Australia could imply that Australia is not contributing very much to the problem. Looking at the CO_2 production per head of population reveals that each Australian is producing a lot more CO_2 than individuals in other countries.

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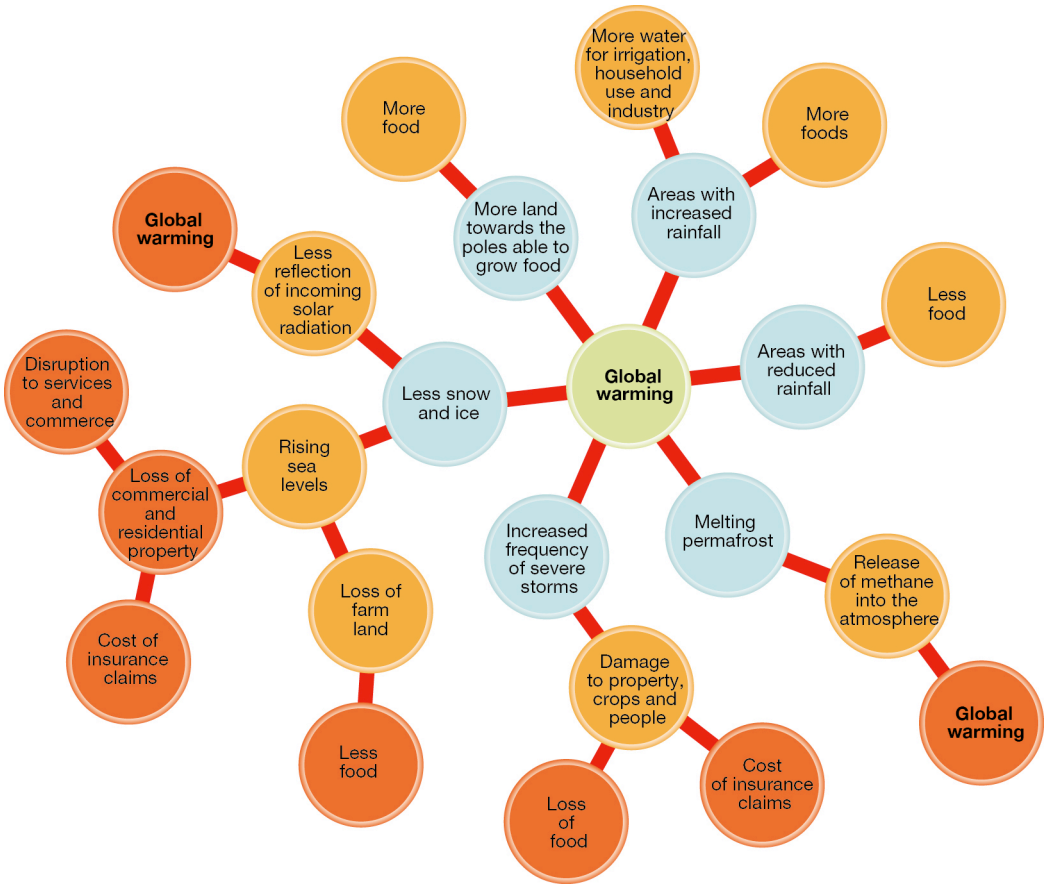
15 The changes caused by increased levels of CO_2 in the atmosphere are long-term changes.

16 Diagrammatic answer (see below)



Unit 6.4

1 Species and ecosystems became extinct.

2 Geology

3 A rise in sea level and an increase in storm activity would cause freshwater areas of Kakadu to be inundated by salt water and become unsuitable for the organisms presently living there. Salt-tolerant species will flourish, changing the ecosystems. Floods would carry weed species and allow feral animals to move into the area.

4 They will move from unsuitable areas towards areas that can provide for their needs.

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5 Urban development and clearing land for agriculture have:

- destroyed some natural ecosystems
- fragmented natural ecosystems, making it more difficult for organisms to move away from unsuitable areas.

6 The symbiotic photosynthetic protists of the corals

7 Storm surges would bring salt water into the low-lying freshwater areas of Kakadu, making them brackish. The natural ecosystems would be destroyed. Organisms that can survive in saline conditions would establish, creating new ecosystems.

8 Carbon credits are awarded to projects that reduce the amount of carbon dioxide in the atmosphere. One carbon credit is the equivalent of reducing the amount of carbon dioxide in the atmosphere by 1 tonne. In this way, an industry can balance the carbon dioxide they produce with the carbon they have stored.

9 The larvae of the starfish and corals could also be carried south and new colonies could establish outside the present range of the species.

10 Planting large numbers of trees will increase the rate at which carbon dioxide is removed from the atmosphere. Removing trees could increase the amount of carbon dioxide in the atmosphere. Atmospheric carbon dioxide has been linked to climate change. Therefore both actions could affect world climate.

11 i a Seeds dispersed by wind

b Wind distributes seeds over a wide area and possibly into suitable environments—outside the previous range. Animals will not disperse seeds as far. This also depends on the animal surviving changing conditions.

ii a Animal that produces a large number of offspring

b A large number of offspring will have more genetic variability (assuming sexual reproduction), increasing the chance that some of the offspring will have characteristics that enable them to survive in the changing conditions.

iii a Plants that survive in a wide range of habitats

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b Plants with specific growing conditions will be adversely affected as soon as conditions change. Plants with wide tolerances should cope with slight changes. These plants are probably found over a much wider area and the conditions in some areas may remain suitable for survival.

iv a Organisms that live in tropical regions

b In a warmer climate, the habitats of organisms adapted to cold conditions will disappear. Organisms adapted to the tropics will be able to spread as Earth warms.

12 If the species change in the wetlands the migratory birds may not have enough food to complete their migration. The populations would be decreased significantly and some species may not survive.

13 a The corals are provided with nutrients from the protists.

b The protists are provided with protection.

14 Water temperature; presence of predators; competitors

15 Kookaburras would compete with other predators. Predator numbers could be reduced.

16 Species vulnerable to grazing could become extinct or reduced in numbers. Species tolerant of grazing would come into the area and the composition of the vegetation would change.

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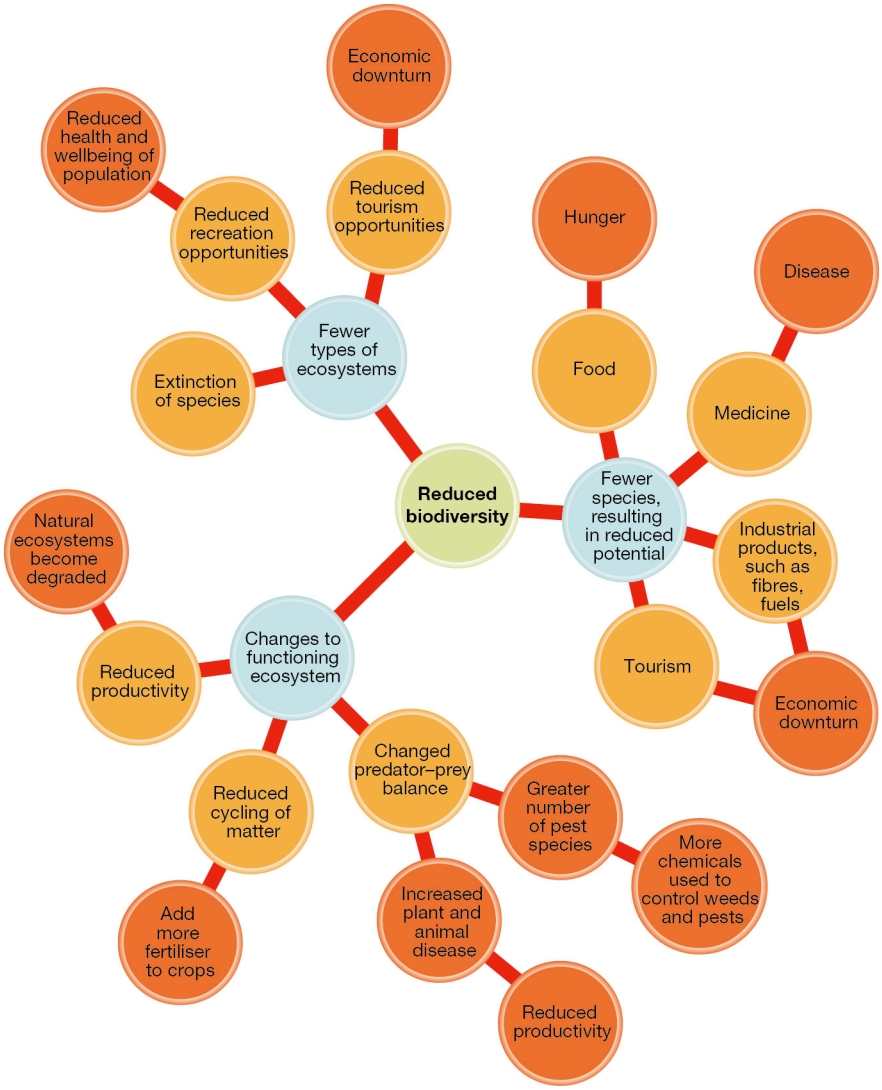
17 Diagrammatic answer (see below)



Chapter review

1 Nitrogen and carbon (may also name oxygen and water)

2 90% found in the stratosphere and some in the mesosphere.

3 The nitrogen cycle and the carbon cycle

4 The ozone layer protects living things from the harmful effects of UV radiation. UV radiation can cause skin cancers and eye disease.

5 Reduced rainfall in the eastern states

6 The more saline the water and the colder the water, the more dense it is. The density of the water determines how quickly it will sink and how deep it will sink.

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7 Reduce production. Remove from the atmosphere and store.

8 Trees take in carbon dioxide and use it in photosynthesis. The products of photosynthesis increase the mass of the tree, about half of which is carbon. Large amounts of carbon are stored in forests and will remain there as long as the tree lives or the wood is still intact as in a building or furniture.

9 **a** 5.5×10^3 million litres

b 2×10^6 million litres

10 Both the greenhouse effect and the enhanced greenhouse effect are the warming of the atmosphere due to the absorption of long-wave radiation by greenhouse gases. The greenhouse effect is a natural process. The enhanced greenhouse effect combines natural warming and warming due to increased greenhouse gases due to human activities.

11 Ocean currents move heat around the globe. Changes to the pattern of heat movement may change the climate of an area. For example, a change in the strength and direction of flow of the Gulf Stream would affect the climate in northern Europe.

12 The present period of warming began when humans were emerging from the Stone Age, long before industrialisation and significant burning of fossil fuels.

13 a,b Adding fertiliser (nitrates) would increase plant growth and the amount of material available for cycling. Decomposer numbers would increase as would bacteria numbers at all other stages of the cycle, including the number of denitrifying bacteria.

Ploughing removes nitrates for soil and would slow the rate of cycling and decrease the numbers of bacteria.

14 As the areas covered in ice diminish, more of the world would be absorbing radiation.

There would be greater reflection in areas with increased rainfall and cloud cover.

Increased vegetation (better growing conditions) would increase absorption.

Decreased vegetation (less rainfall) would increase reflection.

15 Surface currents and the trade winds that cause them will assist the sailors as they move in that direction.

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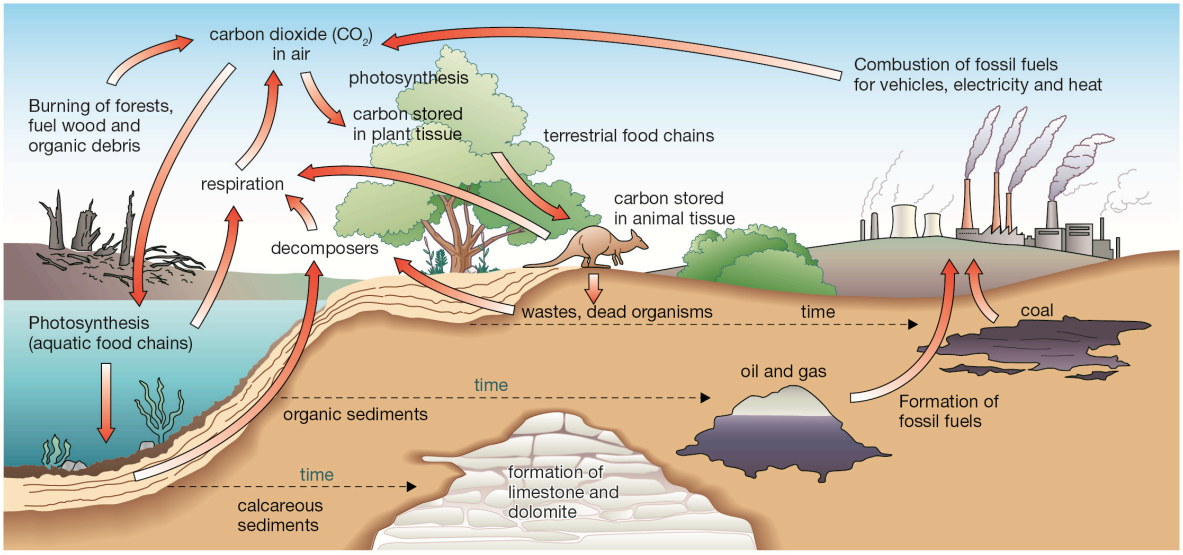
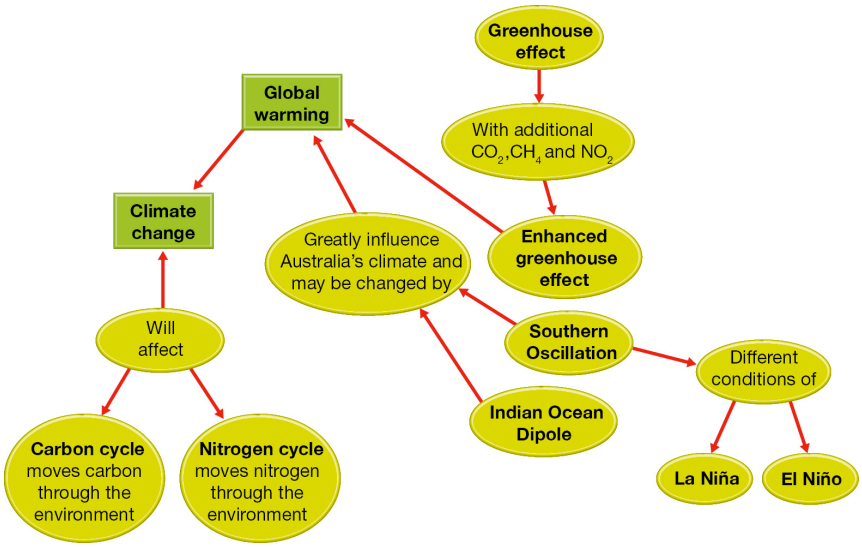
16 Diagrammatic answer (see below)



17 Diagrammatic answer (see below)



Thinking scientifically

Q1 C

Q2 B

Q3 A

Q4 C

Q5 C

Q6 B

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Chapter 7: The universe

Unit 7.1

1 Nuclear fusion

2 White dwarf

3 **a** Spectral class is a measurement of the light emitted by the star. This conveys information about its temperature and composition.

b Spectrometer

4 Apparent magnitude is a measure of how bright a star appears in the night sky whereas absolute magnitude is the brightness of the star if it was 10 pc away. Castor must be a brighter star.

5 A more massive star produces more gravity, which means that fusion occurs more quickly producing more light. This makes the star appear brighter.

6 It will explode as a supernova.

7 **a** 196 pc

b 245 l.y.

8 **a** Rigel appears brighter than Betelgeuse.

b Rigel produces more light than Betelgeuse.

9 **a** 1400 kg/m^3

b 1400 kg/m^3

c 0.000030 kg/m^3

10 Absolute magnitude is a measure of the amount of light produced by a star.

Apparent magnitude is a measure of how bright a star appears from Earth.

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11 **a** 2.6×10^{10} km

b **i** 1.1×10^{9} km

ii 1.8×10^{7} km (18 million km)

c 8.3 light-minutes

d 8.3 minutes

12 Student response.

13 Student response.

14 Student response.

15 Student response.

Unit 7.2

1 Democritus

2 Cepheid variable

3 Red-shift and cosmic microwave background radiation

4 Cosmology is the study of the history and structure of the universe.

5 **a** The light from most galaxies is red-shifted; the further the galaxy is away, the more its light is red-shifted.

b Together, these suggest that the universe is expanding.

6 Cosmic microwave background radiation is the afterglow of the Big Bang that has been red-shifted into the microwave part of the electromagnetic spectrum.

7 It was proposed that material was being spontaneously generated throughout the universe.

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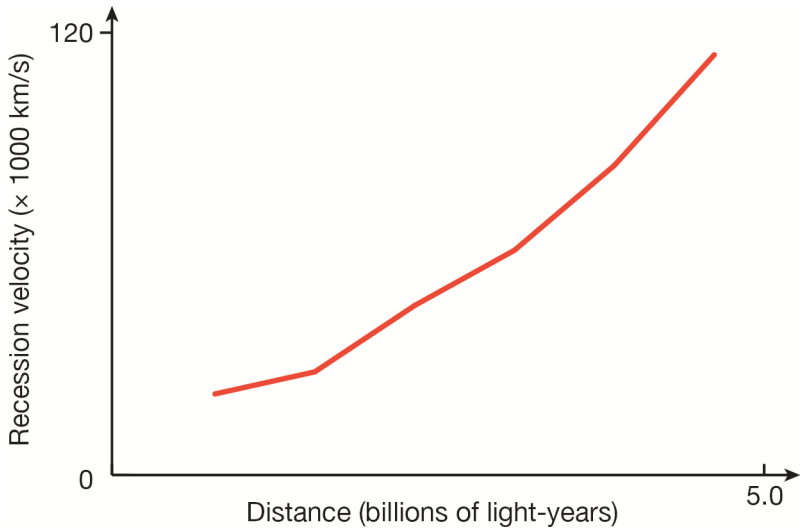
8 a



b $y = 25.4x$ where y is recession velocity (in 1000 km/s) and x is distance (in billions of light-years)

c 71 000 km/s

d 512 million light-years

9 Both red-shift and blue-shift involve a change in the wavelength of light from a star. Light that is red-shifted has had its wavelength increased, whereas the wavelength of light that is blue-shifted has been shortened.

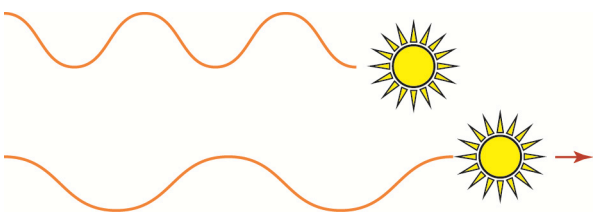
10 The Big Bang theory states that the universe started with a huge explosion of energy, whereas the steady state model says that the universe has always been as it is.

11 The Big Bang occurred 13.7 billion years ago. Light from objects further away than this has not had time to reach Earth.

12 If the universe was contracting, red-shift would become blue shift, i.e. light from distant galaxies would be shifted towards the blue end of the spectrum as the galaxies move away from us.

13 Student response.

14



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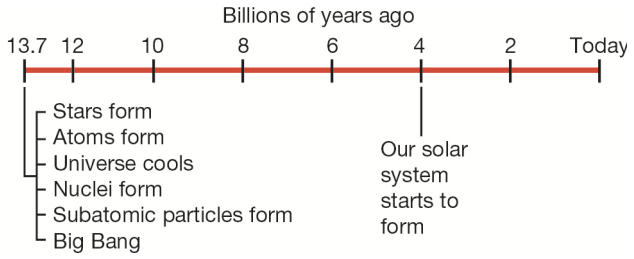

Unit 7.3

1 The gas cloud collapsed, flattened out and started to spin to form a protostar surrounded by a protoplanetary disk. Gravity caused nuclear fusion to start in the protostar. Material in the protoplanetary disk began to accrete into planets.

2 The Moon is relatively large compared to the size of the planet it orbits. It is a lot less dense than most other rocky moons or planets in the solar system. Lunar rocks are very similar in chemical composition to rocks found on Earth.

3 **a** Abiogenesis is the formation of living organisms from inanimate material.

b Panspermia is the theory that life did not evolve on Earth but came to Earth on a comet or meteorite.

4 Earth's orbit is in the 'habitable zone' for temperature, the Moon provides tides and light at night, mass extinctions encouraged opportunities for evolution.

5 Scientists gain information about the internal structure of the Earth from the seismic waves produced by earthquakes.

6 A flask of water simulated the oceans, a flask containing hydrogen, methane and ammonia modelled the early atmosphere, electrodes simulated lightning.

7 A giant impact could explain the Moon's large size; it is not very dense because its iron core has sunk into the Earth and the composition of its rocks is the same as Earth's because they are both made of the same material.

8 Meteorite strikes formed the Moon, created mass extinctions, which encouraged evolution and may have brought the first micro-organisms to Earth. Comet strikes brought water into the Earth's atmosphere.

9 The Moon creates tides, which encourage organisms to migrate from the water, and provides enough light for the evolution of nocturnal organisms.

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10 Like a star, a protostar is an enormous ball of hydrogen gas. Unlike a star, it has not become dense enough for nuclear fusion to occur.

11 Both have a solid core surrounded by layers made of progressively less dense material. Jupiter's outer layers are made primarily of hydrogen and helium whereas Earth's outer layers are made of rock.

12 Since living organisms did not form in the Miller–Urey experiment, it is not conclusive proof that abiogenesis can occur.

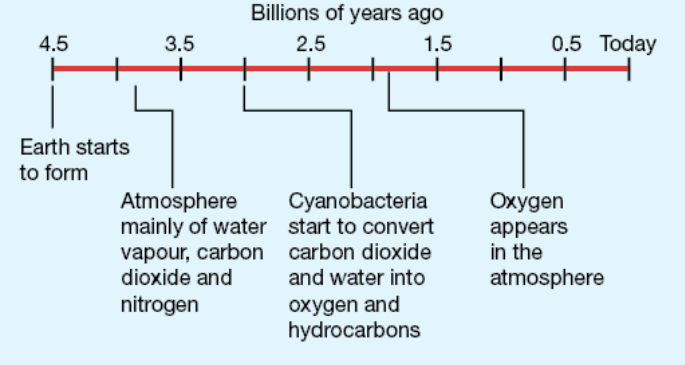
13 **a** It is too hot, there is no water and the crushing, acidic atmosphere would prevent the formation of complex organisms.

b It is too cold and there is no liquid water.

14 **a** This would allow them to compare life on Earth to life on another planet.

b Student response.

15



Chapter review

1 $^{1}H + {}^{1}H \rightarrow {}^{2}H$ + positron + neutrino

2 10 times the mass of the Sun

3 Gravitational lensing and their effect on other stars

4 Edwin Hubble

5 It is possible that micro-organisms could have survived a journey through space to the Earth.

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6 A cloud of gas starts to gather into a protostar, a protoplanetary disk forms around the protostar, the protostar became dense enough for nuclear fusion to occur, protoplanetary disk condense into individual planets, the star burns at a temperature of around 6000°C for about 10 billion years, hydrogen in the core of the star runs out and the star expands to form a red giant, the helium in the core runs out and the outer layers escape to from a planetary nebula, and the remaining material forms a white dwarf, which gradually cools to become a black dwarf.

7 Earth was struck by a Mars-sized meteorite called Theia, large amounts of Earth's mantle were thrown into space to form the Moon, the iron core of Theia sank into the Earth and became part of its core.

8 Banded iron formations in rocks formed at this time.

9 19.9 parsecs

10 **a** Pollux

b Pollux

11 The parallax of another galaxy would be too small to be accurately measured.

12 3300 kg/m^3

13 The Moon is less dense than the Earth because it has no iron core.

14 The apparent brightness is affected by how far away the star is.

15 **a** A parallax method could be used.

b Other planets in the solar system may have moved significantly in the 6 months it takes to make the second parallax measurement.

16 A black dwarf is much smaller than a black hole. It is black because it is cold and does not emit any light. A black hole is black because its gravitational field is so strong that no light can escape it.

17 It is highly unlikely that a black hole would be a gateway to anywhere. An object that travelled to a black hole would be crushed by its immense gravitational field.

18 Elements that we are formed from such as carbon and oxygen were first created within stars.

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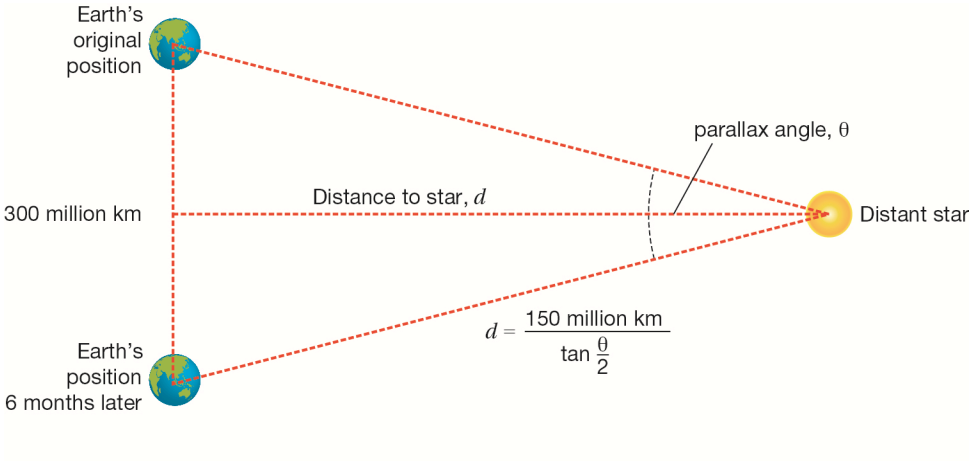
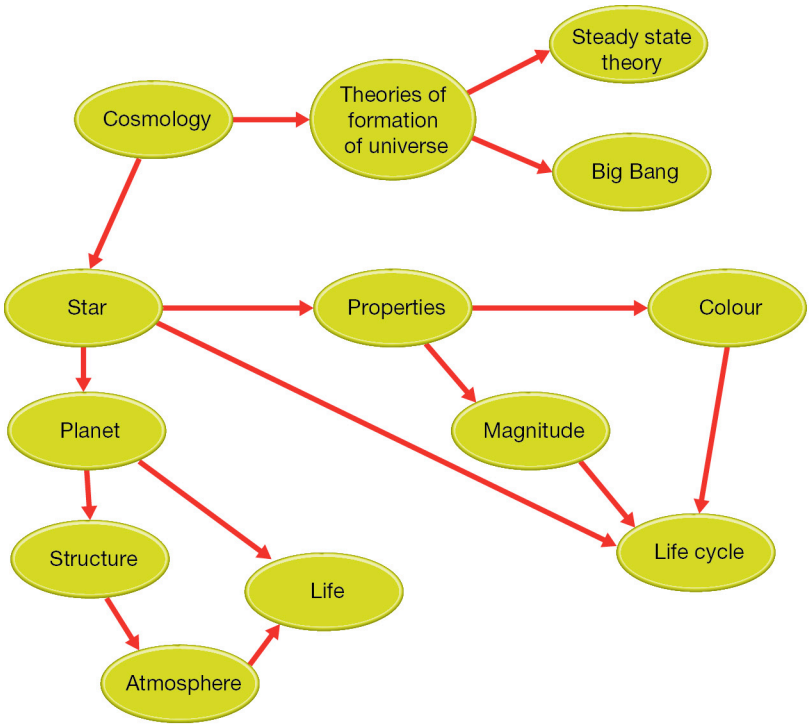


20 Diagrammatic answer (see below)



Thinking scientifically

Q1 D

Q2 C

Q3 A

Q4 D

Q5 C

Q6 C

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Chapter 8: Motion and energy

Unit 8.1

1 B, D

2 **a** False

b False

c True

d True

3 This means that Jo's final point on a journey is 100 m away from where she started, in the direction of north.

4 If you walk from your house, around the block and return home, then your displacement is zero. If you walk from your home to that of a friend, a certain distance away, then your displacement is not zero.

5 Jane is incorrect. Raj's speed remains constant, but because he changes direction as he runs, Raj's velocity changes throughout the journey.

6 A measurement that is accurate is close to the actual value being measured. Measurements that are precise are close to each other. Precise measurements may or may not be accurate.

7 A measuring device may be incorrectly assembled or incorrectly calibrated. This may produce precise results but results that are inaccurate due to a systematic error. Retesting using a different device will show if there was a systematic error involved with one of the measuring devices.

8 **i** **a** 200 + 300 + 200 = 700 m

b 3 + 1 + 4 + 1 = 9 km

c 2 + 6 + 3 + 2 + 1 = 14 m

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ii **a** 300 m east

b 1 km south

c 4 m west

9 **a** **i** Mitsu's average speed over the first 2 hours

$= \frac{d}{t} = \frac{0.4}{2} = 0.2$ km/h

ii Returning from her friend's house over the last hour

$= \frac{d}{t} = \frac{0.4}{1} = 0.4$ km/h

b This represents the time period of 2 hours in which Mitsu is visiting her friend.

c Mitsu has reached home at the end of the journey because her displacement is zero at this point.

10

Animal	Speed (m/s)	Speed (km/h)
Cheetah	28.3	102
Red kangaroo	17.5	63
Giraffe	15.6	56
Emu	13.9	50
Human	7.5	27
Elephant	6.7	24
Chicken	4	14.4
Giant tortoise	0.075	0.27

11 **a** Tim's average speed = = = 5 km/h

b The frog's average spe $\frac{d}{t}$: $\frac{d}{t}$ $\frac{0}{2}$ $\frac{16}{4}$ = 4 m/s

c distance = 3 km

time = 6 min = $\frac{6}{60}$ hours = 0.1 hours

speed = $\frac{3}{0.1}$ = 3 km/h

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12 **a** A stationary object: D

b An object moving backwards: E, F

c The fastest forward moving object: A

d The fastest backward moving object: F

13 The driver is initially travelling at:

$\frac{80}{3.6}$ = 22 m/s

In taking 0.75 s to react, the car travels:

22 × 0.75 = 16 m

The total distance the car takes to stop

= reaction distance + braking distance

= 16.5 + 39.2 = 55.7 m

14 Distance is a total length measurement. Displacement is the distance an end point is from the starting point, but also specifies the direction of the end point from the starting point.

15 The distance each car has travelled in the first 20 seconds can be calculated from the area underneath the graph to this point.

Car A travels: (4 × 20) = 80 m

Car B travels: (0.5 × 10 × 4) + (0.5 × 16 × 10) = 20 + 80 = 100 m

This means that in 20 seconds, car B has travelled further than car A.

16 **a** Systematic error because the method of measuring has an inbuilt, constant sized error

b Random error due to parallax error in trying to read the scale from above

c Random error due to a miscount

d Systematic error due to a constant addition to the time that the stop watch will record for every measurement

17 **a** Systematic error

b The equipment used to grind the surface of the mirror was incorrectly assembled. This resulted in a systematic error that affected the results of using this equipment.

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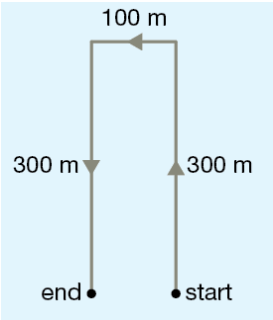
18 a Catarina has travelled: 300 + 100 + 300 = 700 m

b Catarina's average speed (in m/s)

$$= \frac{d}{t} = \frac{700}{(5 \times 60)} = 2.3 \text{ m/s}$$

c



d Catarina's displacement is 100 m west.

e Catarina's average velocity

$$= \frac{\text{displacement}}{\text{time}} = \frac{100}{300} = 0.3 \text{ m/s west.}$$

Unit 8.2

1 average acceleration $= \frac{\text{change in speed}}{\text{time}}$

$$= \frac{\text{final speed} - \text{initial speed}}{\text{time}}$$

or

$a = \frac{v - u}{t}$, where a is acceleration, v is final speed, u is initial speed and t is time taken

2 The SI units for acceleration are m/s/s or m/s^2; however, other units can also be used, such as km/h/s.

3 Human tolerance of g-forces depends upon how big they are, how long they last, the direction in which they act and the part of the body they affect.

4 The gradient of a speed–time graph is acceleration.

5 An object dropped from a height on Earth will be slowed by the force of air resistance.

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6 Forces experienced in a vertical drop are extremely dangerous as blood rushes to the head and can cause loss of consciousness or death.

7 A train travelling at 8 m/s^2 is speeding up at the rate of 8 m/s every second. A train travelling at –8 m/s^2 is slowing down at the rate of 8 m/s every second.

8 **a** 0.2 m/s

b 0.4 m/s

c 0.6 m/s

d 2.0 m/s

9

Car	Time (s)	Average acceleration (km/h/s)
Nissan GT-R	3.5	$\frac{100}{3.5} = 28.6$
BMW 135i	5.6	$\frac{100}{5.6} = 17.9$
Volkswagen Golf GTI	7.3	$\frac{100}{7.3} = 13.7$
Ford FG Falcon	7.3	$\frac{100}{7.3} = 13.7$
Holden VE Commodore	8.1	$\frac{100}{8.1} = 12.3$
Honda Civic	9.8	$\frac{100}{9.8} = 10.2$
Toyota Tarago	17.7	$\frac{100}{17.7} = 5.6$

10 **a** John Strapp's speed = $\frac{1017}{3.6}$ = 282.5 m/s

His acceleration in reaching this final speed in 5 seconds is:

$$a = \frac{v - u}{t} = \frac{282.5}{5} = 56.5 \text{ m/s}^2$$

b His deceleration in coming to a stop is:

$$a = \frac{v - u}{t} = \frac{-282.5}{1} = -282.5 \text{ m/s}^2$$

11 **a** The leaf is initially travelling quite fast, at 12 m/s. Its speed slows down until it stops for an instant at 6 seconds. Its speed increases over the next 2 seconds, so the leaf travels at 6 m/s. It continues at this constant speed for the rest of the time indicated on the graph.

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b Acceleration of the leaf in the first 6 seconds:

$$a = \frac{v - u}{t} = \frac{0 - 12}{6} = -2 \text{ m/s}^2$$

c The distance it travelled in this time

= area below the speed–time graph

= ½ × 12 × 6= 36 m

d Acceleration between 6 and 8 seconds of its journey:

$$a = \frac{v - u}{t} = \frac{6 - 0}{2} = 3 \text{ m/s}^2$$

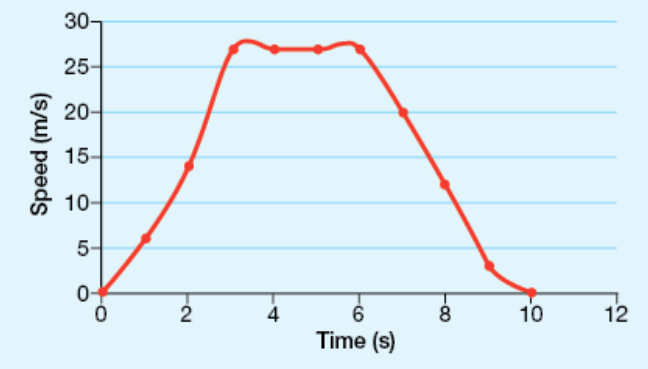
12 a Speeding up: graph b

b Slowing down: graph c

c Travelling at constant speed: graph a

13 Individual student response about factors they would consider when purchasing a car. For example: cost, safety rating, greenhouse emissions, fuel economy, availability of spare parts

14 a



b **i** 3–6 seconds

ii 0–3 seconds

iii 6–10 seconds

15 Individual student response in which a situation is described in which:

From 0 to 10 seconds: an object travels at a constant speed of 5 m/s.

From 10 to 15 seconds, the motion steadily slows to a stop. From 15 to 25 seconds, speed increases steadily to 3 m/s; and continues at this speed for the next 10 seconds.

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Unit 8.3

1 Newton's first law of motion states that:

- an object at rest will remain this way unless it is acted upon by a force
- an object that is moving will continue to move at the same speed and in the same direction unless a force acts upon it.

2 **a** Newton's second law of motion:

$F_{net} = m \times a$

where *F*net is the total force acting on an object measured in newtons (N), *m* is the mass of the object (kg) and *a* is the acceleration of the object (m/s^2).

b $a = \frac{F_{net}}{m}$

3 *Voyager 1* is still in motion because no force has acted upon it to stop its motion.

4 If a car collides with a stationary object, such as a pole, the occupants of the car continue to travel forward with the speed that they had before the impact. This means that if the driver or a passenger is forced against a sharp object, such as a radio dial in the front of the car, this could cause damage in an accident. Similarly, loose objects in the back of the car will continue to travel forward in such an accident and can hit an occupant in the front of the car.

5 The car will only accelerate, i.e. increase or decrease speed, if unbalanced forces are acting upon it. If the forces on the car are balanced, then its acceleration is zero; the car may be travelling at a constant speed, in which case its acceleration is zero.

6 An airfoil describes the cross-sectional shape of an aircraft wing. The base of the wing is flat and the top surface is curved. Air flows more rapidly over this top curved surface, which creates a lift force.

7 The racquet applies an action force to the tennis ball upon impact. The ball applies an equal and opposite reaction force back on the racquet.

8 Objects with more mass possess greater inertia. Therefore, the suitcase packed for a holiday has greater inertia than the same suitcase when it is emptied.

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9

Net force (N)	Mass (kg)	Acceleration (m/s^2)
24.0	6.0	4.0
13.5	3.0	4.5
87.0	58.0	1.5
87.5	25.0	3.5
1160.0	80.0	14.5
5.5	5.0	1.1

10 a $F_{net} = m \times a$

$= 1740 \times 3$

$= 5220$ N

This is the net force required for the Nissan GT-R to accelerate at 3 m/s^2.

b If there was a 2000 N force of friction opposing the car's motion, then the driving force would need to be 2000 N + 5220 N = 7220 N.

In other words, a driving force of this size would result in a net force of 5220 N once the effect of friction has been removed. This net force is required to maintain an acceleration of 3 m/s^2.

11 a net force = 60 N – 30 N = 30 N to the right

$a = \frac{F_{net}}{m} = \frac{30}{20} = 1.5$ m/s^2 to the right

b net force = 250 N – 100 N = 150 N up

$a = \frac{F_{net}}{m} = \frac{150}{75} = 2.0$ m/s^2 up

c net $\frac{F_{net}}{m}$ 8C $\frac{1650}{1500}$) N = 1650 N to the right

$a =$ $=$ $= 1.1$ m/s^2 to the right

12 The lift force created points to the centre of the boomerang's flight path.

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13

	Action force	Reaction force
a	Mylinh's foot pushes back on the footpath as she walks down the street.	The footpath pushes upwards on Mylinh's foot.
b	Ted applies a force to a cricket ball as he catches it.	The cricket ball exerts a force on Ted's hand.
c	Sally pushes on the handle of a lawnmower.	The handle of the lawnmower pushes back on Sally's hand.
d	Alf pushes a punching bag.	The punching bag pushes back on Alf.
e	Jade pushes on pizza dough as she kneads it.	The pizza dough pushes back on Jade's hands.

14 a 17 m/s = (17 × 3.6) km/h= 61.2 km/h

b Phil's acceleration = $\frac{v-u}{t} = \frac{17}{4} = 4.25$ m/s^2

c $F = ma = 190 \times 4.25 = 807.5$ N

15 The acceleration is the same as in question 14.

$F = ma = 150 \times 4.25 = 637.5$ N

16 a The combined mass of Yen and Phil's bike is 150 kg.

b Yen's acceleration is:

$$a = \frac{F}{m} = \frac{807.5}{150} = 5.38 \text{ m/s}^2$$

c After 4 seconds, Yen's speed is

$v = u + at$

$= 0 + (5.38 \times 4)$

$= 21.5$ m/s

17 a The combined mass of Phil and Yen's bike = 190 kg

b Phil's acceleration is:

$$a = \frac{F}{m} = \frac{637.5}{190} = 3.36 \text{ m/s}^2$$

c After 4 seconds, Phil's speed is

$v = u + at$

$= 0 + (3.36 \times 4)$

$= 13.44$ m/s

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18 a As the acceleration, $a = \frac{F}{m}$, if the force is doubled, then the acceleration is also doubled.

b As the acceleration, $a = \frac{F}{m}$, if the force is halved, then the acceleration is also halved.

c As the acceleration, $a = \frac{F}{m}$, if the mass is doubled, then the acceleration is halved.

d As the acceleration, $a = \frac{F}{m}$, if the force and the mass are doubled, then the acceleration is unchanged.

Unit 8.4

1 a Joules

b Joules

2 Kinetic energy is calculated using the equation $E_k = ½mv^2$.

3 A car has more kinetic energy when travelling at 60 km/h compared to travelling at 10 km/h.

4 The amount of gravitational potential energy possessed by an object depends upon its mass, position (h), and the gravitational field strength of the object's location.

5 Student response, for example a trampoline, car bumpers, bungee cords, slingshots and tennis balls use elastic potential energy to do work.

6 a The gravitational potential energy will double.

b The kinetic energy increases by a factor of 4.

7 The kinetic energy of a moving object can be transferred to another object, applying a force to make it move some distance. An object with potential energy, such as a ball that falls from a ledge can also cause another object to move a certain distance. In each case, work is done.

8 a Work done = $F \times s = 250 \times 1.5 = 375$ J

b Power = $\frac{\text{work done}}{\text{time}} = \frac{375}{5} = 75$ W

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9 **a** Work is done.

b No work is done.

c Work is done.

d No work is done.

10 **a** $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 80 \times 42 = 640$ J

b Speed = 54/3.6 = 15 m/s

Kinetic energy of the bus is

$E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 10\,000 \times 152$

$= 1\,125\,000$ J $= 1.125$ MJ

c Convert the mass of the tennis ball into kg.

100 g $= \frac{100}{1000} = 0.1$ kg

$E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.1 \times 302 = 45$ J

11 **a** $E_p = mgh = 0.5 \times 9.8 \times 20 = 98$ J

b $E_p = mgh = 20\,000 \times 9.8 \times 300 = 58\,800\,000$ J

c $E_p = mgh = 2 \times 9.8 \times 2 = 39.2$ J

12 **a** Gravitational potential energy before the ball is dropped

$= mgh$

$= 1 \times 9.8 \times 2$

$= 19.6$ J

b The instant that the ball hits the ground, its height is zero and so its gravitational potential energy is zero. The initial amount of gravitational potential energy, 19.6 J, has been converted its kinetic energy at this point.

c When the ball hits the ground, its kinetic energy is 19.6 J.

$E_k = \frac{1}{2}mv^2$

$19.6 = \frac{1}{2} \times 1 \times v^2$

So $v^2 = 19.6 \times 2 = 39.2$

$v = \sqrt{39.2} = 6.3$ m/s

13 The kinetic energy of a car that is involved in an accident is transferred to its surroundings and does work when applying an impact force to push or twist other objects. Because kinetic energy is $\frac{1}{2}mv^2$, a fairly small increase in the speed of a

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car translates to a much larger increase in kinetic energy because this value is squared in the equation. As a result, the risk of serious injury or death increases sharply for all increases of speed over 60 km/h.

14 a The gravitational potential energy at the top of hill 1:

$mgh = 1500 \times 9.8 \times 7 = 102\,900$ J

b Because the roller coaster started from rest, the total energy of the system is 102 900 J.

The gravitational potential energy at the top of hill 2:

$mgh = 1500 \times 9.8 \times 3 = 44\,100$ J

Kinetic energy at the top of hill 2:

102 900 – 44 100 = 58 800 J

c At the top of hill 3: Gravitational potential energy:

$mgh = 1500 \times 9.8 \times 5 = 73\,500$ J

Kinetic energy at the top of hill 3 is:

102 900 – 73 500 = 29 400 J

d Kinetic energy at the top of hill 3 is 29 400 J

So $29\,400 = \frac{1}{2}mv^2 = \frac{1}{2} \times 1500 \times v^2$

and $v^2 = 29400/750$

Taking the square root of both sides, the speed of the rollercoaster over hill 3 is approximately 6.3 m/s.

e If friction was taken into account, a significant amount of the original potential energy would be converted to heat as the rollercoaster moves along the track. In real life, the rollercoaster will not travel quite as fast as the speeds predicted here.

15 If a latter hill was larger than the first, the cart could only climb it if an additional source of energy was provided.

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Chapter review

1 SI units: kilogram, second

2 To convert a speed from km/h into m/s, divide by 3.6.

3 **a** Speed

b Acceleration

4 If a horse stops running when it comes to a fence, the motion of its rider continues unless it is stopped by another force. This happens due to the rider's inertia. The rider continues to travel forwards until something stops its motion.

5 Wearing a helmet when riding a bike reduces the force of an impact if the rider is involved in a collision because its cushioning increases the time over which the accident occurs.

6 **a** From the graph, the total distance Steve travelled = 6 + 6 = 12 km

b Steve's displacement = zero

c His speed in the first 2 hours:

$$\frac{\text{distance}}{\text{time}} = \frac{6}{2} = 3 \text{ km/h}$$

d Steve was stationary between 2 and 3 hours.

e Steve's speed in the last 3 hours of his journey:

$$\frac{\text{distance}}{\text{time}} = \frac{6}{3} = 2 \text{ km/h}$$

f Steve's average speed over the entire trip:

$$\frac{\text{distance}}{\text{time}} = \frac{12}{6} = 2 \text{ km/h}$$

7 **a** Each second, Carlo's speed increased by 0.1 m/s.

This means that over 3 seconds, his speed increased by 0.3 m/s.

After 3 seconds, Carlo's speed is:
(0.2 + 0.3) = 0.5 m/s

b 0.5 m/s = (0.5 × 3.6) km/h

= 1.8 km/h

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8 By Newton's second law:

$F = ma$

and $a = \frac{F}{m} = \frac{7}{5} = 1.4 \text{ m/s}^2$

The toolbox accelerates at 1.4 m/s^2.

9 **a** $E_k = ½mv^2 = ½ \times 0.1 \times 22 = 0.2$ J

The apple has 0.2 J of kinetic energy.

b $E_k = ½mv^2 = ½ \times 75 \times 52 = 940$ J

The athlete runs with 940 J of kinetic energy.

c $E_k = ½mv^2 = ½ \times 2500 \times (80/3.6)2$
$= 620\,000$ J

The delivery van travels with 620 000 J or 620 kJ of kinetic energy.

10 Calculate the potential energy of:

a $E_p = mgh = 9 \times 9.8 \times 7 = 617.4$ J

The rock has 617.4 J of potential energy.

b $E_p = mgh = 80 \times 9.8 \times 40 = 31\,360$ J

The man has 31 360 or approximately 31 kJ of potential energy.

c $E_p = mgh = 15 \times 9.8 \times 20 = 2940$ J

The chimpanzee has 2940 J of potential energy, or almost 3 kJ.

11 **a** Work done = area below this graph
= 250 × 2 = 500 J

b Work done = area below this graph
= 250 × 6 =1500 J

12 The missing values are:

$E_k = 3750$ J

$E_k = 7500$ J

$E_p = 3750$ J

$E_p = 0$ J

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13 a This object is travelling at a constant speed.

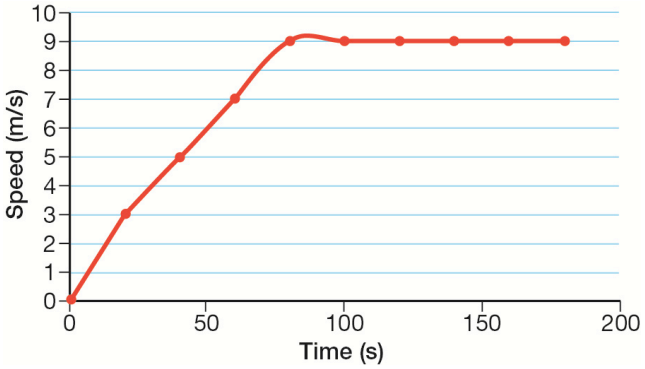
b This object accelerates at a constant rate, then travels at a constant speed for a certain time before undergoing constant deceleration to come to a stop.

c This object travels at a constant speed for a short time, then undergoes constant but rapid deceleration to slow to a stop for some time. After this, it accelerates rapidly at a constant rate to travel at its original speed. It then continues to travel at this constant speed.

14 When a rollercoaster turns a sharp left, your body continues to travel in its original straight-line path, as predicted by inertia. As the cart turns, you experience this continuation of your motion as a lean to the right-hand side.

15 As the lift moves upwards, your body had a tendency to remain stationary in its position on the ground. As a result, you feel heavier than normal as your body is pushed upwards with the moving lift.

16 a Speed of Newton's Wings



b Newton's Wings top speed is 9 m/s.

In km/h this is (9 × 3.6) = 32.4 km/h.

c The distance run by Newton's Wings in the race can be calculated as the area below the speed–time graph.

Area below graph

= (½ × 9 × 80) + (9 × 100)

= 360 + 900 = 1260 m

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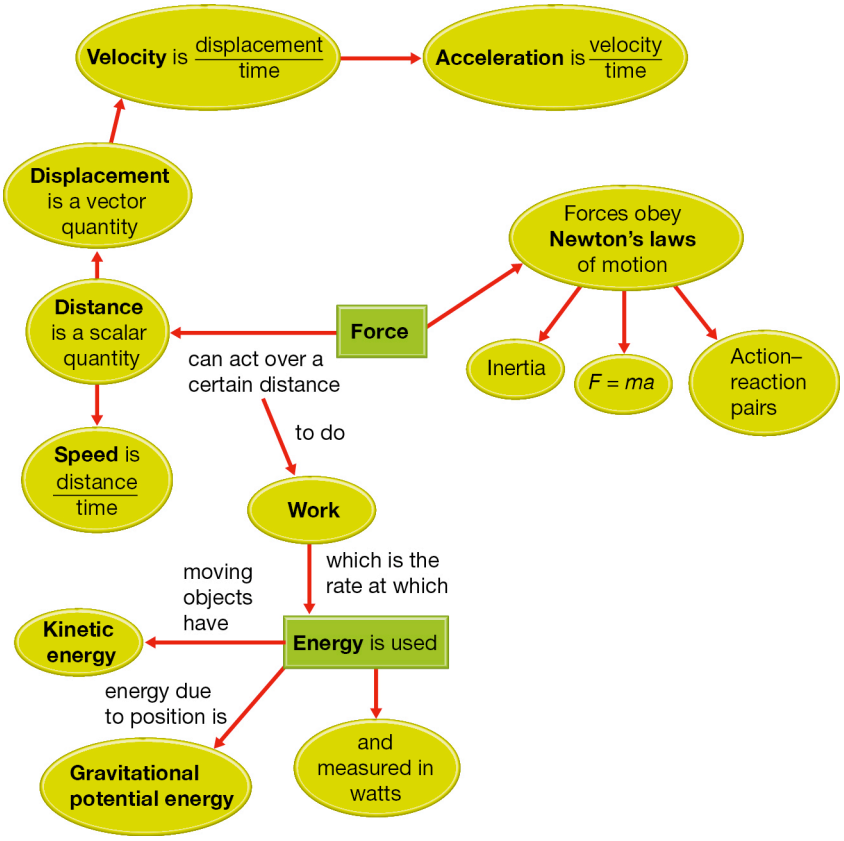
17 Individual student response (see example below).



Thinking scientifically

Q1 C

Q2 A

Q3 B

Q4 C

Q5 D

Q6 C

Q7 B

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Chapter 9: Structures

Unit 9.1

1 **a** Compression

b Tension

2 Granite, bone, marble, brick and pine, concrete

3 **a** Brick, concrete, marble, granite

b Carbon fibre, Kevlar, nylon fibre

c Reinforced concrete, steel, timber

4 **a** The hose would be tight, like a rope.

b The hose would twist and bend, forming snake-like S shapes.

5 A scratch reduces the cross-sectional area of a wire. As area reduces, stress increases. Hence, a scratch increases the stress at that point. Therefore, the 'effective' tensile force on the material at that point is greater than anywhere else in the material. It stretches more, reduces cross-sectional area more and therefore increases the stress at that point even more. Hence, once scratched, the wire is most likely to break at the scratch.

6 Kevlar is very strong under tension but extremely weak under compression. The sails of a yacht are being stretched by the wind and so are under tension. Kevlar can easily resist these tensile forces. Hence, the sail will not rip.

7 **a** B

b C

c A

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8 **a** Tension

b Compression

c Tension

d Compression

e Tension

9 The same force is being applied whether it is being applied via an open hand or a finger. However, a pointed finger has far less area than the open hand. Hence, the pointed finger applies a far greater stress on a material (e.g. you) than an open hand. Hence, you feel it more.

10 **a** Maximum compressive stress for granite = 240 MN/m^2,
concrete = 20 MN/m^2. Hence granite is $\frac{240}{20}$ = 12 times stronger under compression than concrete.

b Maximum compressive stress for granite = 240 MN/m^2,
marble = 80 MN/m^2. Hence granite is $\frac{240}{80}$ = 3 times stronger under compression than marble.

11 **a** Maximum tensile stress for carbon fibre = 5560 MN/m^2,
nylon = 500 MN/m^2. Hence carbon fibre is $\frac{5560}{500}$ = 11.12 or roughly 11 times stronger under tension than nylon.

b Maximum tensile stress for carbon fibre = 5560 MN/m^2,
pine = 40 MN/m^2
Hence carbon fibre is $\frac{5560}{40}$ = 139 times stronger under tension than pine.

12 Stress on A = 2/1 = 2 MN/m^2

Stress on B = 2/0.5 = 4 MN/m^2

Stress on C = 4/2 = 2 MN/m^2

Stress on D = 1/0.5 = 2 MN/m^2

Hence, B is under the greatest stress.

13 **a** Tension

b Compression

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14 a Balanced

b Unbalanced

c Unbalanced. (Balanced vertically but unbalanced horizontally.)

15 a Tension

b Compression

16 a I = compression

b II = tension

c III = tension

IV = compression

V = tension

d VI = tension

VII = compression

VIII = tension

17 a Various answers possible depending on their justification in part b.

b If something is not moving, it either means that there are no forces on it (unlikely) or that all the forces on it are balanced and add to zero.

18 Timber is relatively cheap, light, strong under compression and tension, easy to cut and assemble and easy to attach to different coverings (e.g. brick, timber, cement sheeting).

19 Aluminium is strong under compression and tension and can be moulded and shaped into different forms. More importantly, it is much lighter than comparable metals.

20 People exert the same force on the floor (their weight) regardless of what shoes they wear. High-heeled shoes have a very small surface area in contact with the floor and so the stress on the floor is very high. This is more likely to damage the floor than a flatter soled boot, which spreads the weight and so reduces the stress on the floor.

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21 The sharp tip of a nail increases the stress on the material the nail is being hammered into. A flatter tip would spread the force over a wider area and exert less stress on the material. Hence a flat-tipped nail would have little effect on the material or would require a far greater hitting force to have the same effect.

Unit 9.2

1 **a** Great Pyramid of Khufru 147 m

b Eiffel Tower 300 m

c Burj Khalifa 818 m

2 The 1871 fire of Chicago

3 **a** The forces on the forks are balanced.

b When balanced, the overall force is zero.

4 Limestone is strong under compression and can be cut to make different shapes, allowing the blocks to fit neatly together.

5 Towers made of stone or brick need very strong lower walls. The walls need to be thick and have few openings such as windows or doors. Hence, living in them would be cramped and dark.

6 The Leaning Tower of Pisa was straightened by attaching cables that gradually pulled it upright. Lead weights were added to the north side while a cavity was dug below that side, allowing the tower to sink.

7 **a** Different criteria are used to determine height, such as the very tip, top of the architecture, the roof and the highest occupied floor.

b Although Q1 is taller to the peak of its architecture, the roof and highest occupied floor of Eureka is higher.

8 Similarities: both have a frame, both cover the frame in lightweight materials

Differences: size, timber is commonly used in a house while steel or reinforced concrete is used in a skyscraper.

9 The person on the left is stable while the person on the right will topple over.

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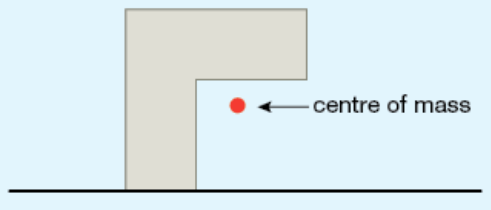
10 Erosion has worn down the pyramid. Also, stone has been stolen from it over the centuries to build other structures.

11 Cities would have much shorter buildings and so would need to spread out further to accommodate everyone.

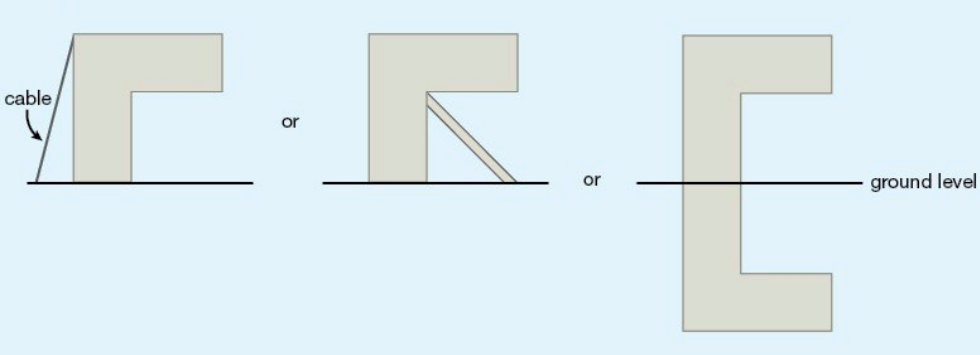
12 Four-wheel-drive cars are much taller than normal cars and have higher centres of mass. Therefore, on a slope, it is more likely that the weight force of a 4WD car is acting outside its base than with a normal car. Hence, 4WD cars are more likely to topple over.

13 By bending their knees, skiers lower their centre of mass. This makes them more stable and less likely to topple over because it increases the chance that their weight force will act through their base.

14 a



b



Unit 9.3

1 a Post and beam structures need many support columns if they are to cover large distances. Materials need to perform well under both compression and tension.

b Arches are difficult to build and can only be built with materials that work well under compression.

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2 **a** Gothic arch

b Post and beam

c Roman arch

3 **a** Concrete, stone, brick

b Steel, wood

4 Compression

5 **a** The two people should be able to lean into each other without slipping over or collapsing.

b Their feet will be more likely to slip and the ‘arch’ will collapse.

c A foot stopping them from slipping should allow them to produce wider and wider arches by leaning over more and more.

6 The Parthenon is a post and beam structure made of stone. Stone is good in compression but not in tension. Both compression and tension are shown in beams and they will fail if not supported.

7 **a** A lintel is a horizontal beam that holds up the weight of a wall and roof.

b They are commonly found over windows and doors.

8 Beams are under compression and tension. Timber and steel are good under both compression and tension.

9 **a** Reinforced concrete is concrete with steel rods or mesh inserted while it is setting.

b Normal concrete is only good under compression and crumbles under tension. Reinforced concrete is good under compression and tension.

10 **a** Roman arches send their weight force more horizontally than Gothic arches. This required thick walls to stop the arch collapsing and the walls from toppling over.

b Any openings such as windows will weaken the walls.

11 Most types of stone are strong under compression but weak under tension. All the materials in a Roman or Gothic arch are under compression. Hence stone is an ideal material from which to construct them.

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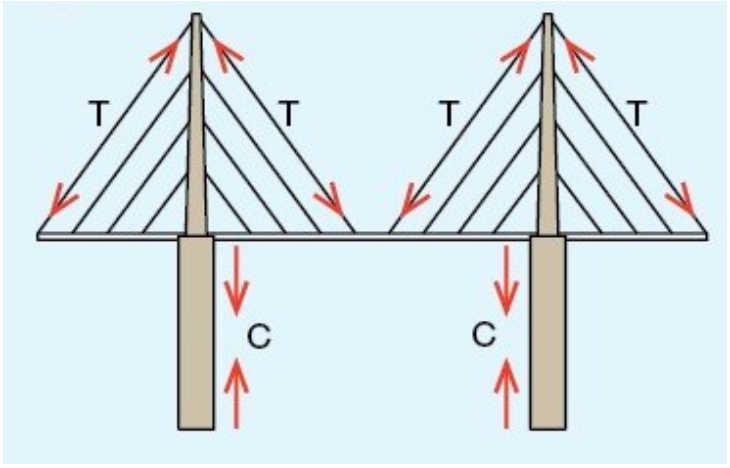
12 Flying buttresses give relatively thin walls extra support, stopping the walls from toppling over under the weight of the arch, walls and roof above.

13 Gothic churches use Gothic arches to frame their structures, windows and doorways. Being high and pointed, the weight force is transferred through a Gothic arch relatively vertically to the ground. Hence, the walls do not have to withstand high sideways forces that would cause them to topple. So the walls can be made thin or even as windows. Any extra support is provided by flying buttresses. Being separate from the wall itself, the flying buttress allows windows to be inserted in the wall.

14 A—flying buttress, B—Gothic arch

15



16 Roman arches support Richmond Bridge.

17 **a** A Roman arch is semicircular while a Gothic arch comes to a point.

Roman arches require thicker walls than Gothic arches because their weight is transferred to the ground more horizontally.

b A suspension bridge hangs cables vertically off another cable which is strung between columns or pillars. A cable-stayed bridge uses angled cables to support a cantilever bridge.

18 The Romanesque period used Roman arches.

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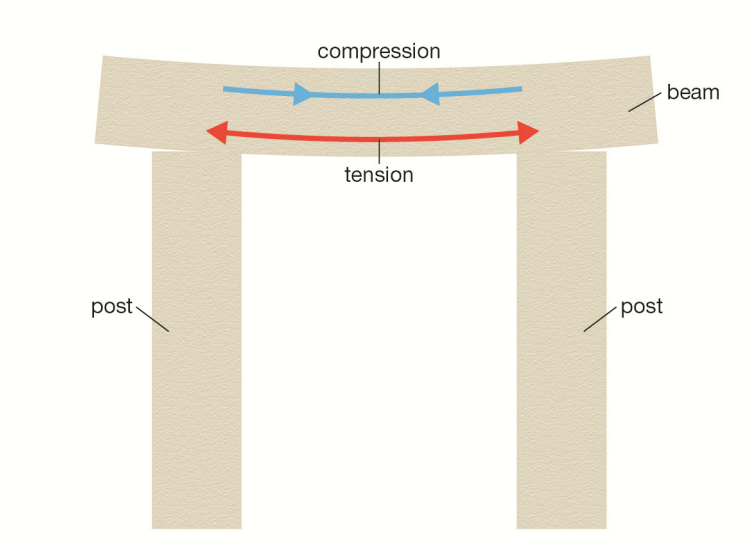
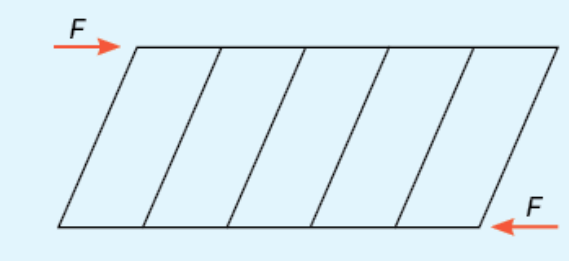
19 Diagram should be similar to Figure 9.3.1 (see below).



20 **a** Diagram required showing the rectangle being pushed into a parallelogram shape.



b Triangles do not deform or change shape like rectangles. Hence, trusses made from them will not deform either.

Chapter review

1 Cracks, doors and windows ‘sticking’ or loose, plaster bulges in walls.

2 That part of the building might fail or collapse, destroying the balance of forces in other parts of the building. The whole building might then collapse.

3 **a** Timber is relatively cheap, light and easy to work. It is good under both compression and tension and so can be used in different situations.

b Steel is very strong and is good under compression and tension.

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4 Kevlar is roughly seven times stronger than nylon under tension. Wind stretches sails and places them under tension. Hence, Kevlar sails are seven times less likely to tear than nylon sails.

5 The angle was changed to make it shorter, lighter and less likely to collapse.

Pharaoh Snefru was about to die and the pyramid needed to be completed before his death.

6 To the:

- tip of the building
- top of its roof
- highest occupied floor
- highest part of the building, not including 'add-ons' such as antennae and flag poles

7 Beyond ten storeys, the walls of a stone or brick tower are too thick at the base to make it practical.

8 You need to ensure that your centre of mass is directly above the base formed by your two hands on the ground. In this way, your weight force passes through your base.

9 The Parthenon is made of stone, which is good under compression but not under tension. Without supporting columns, the beams would crack.

10 **a** Brick, stone, concrete

b Kevlar, carbon fibre

c Wood, reinforced concrete

d Steel, nylon

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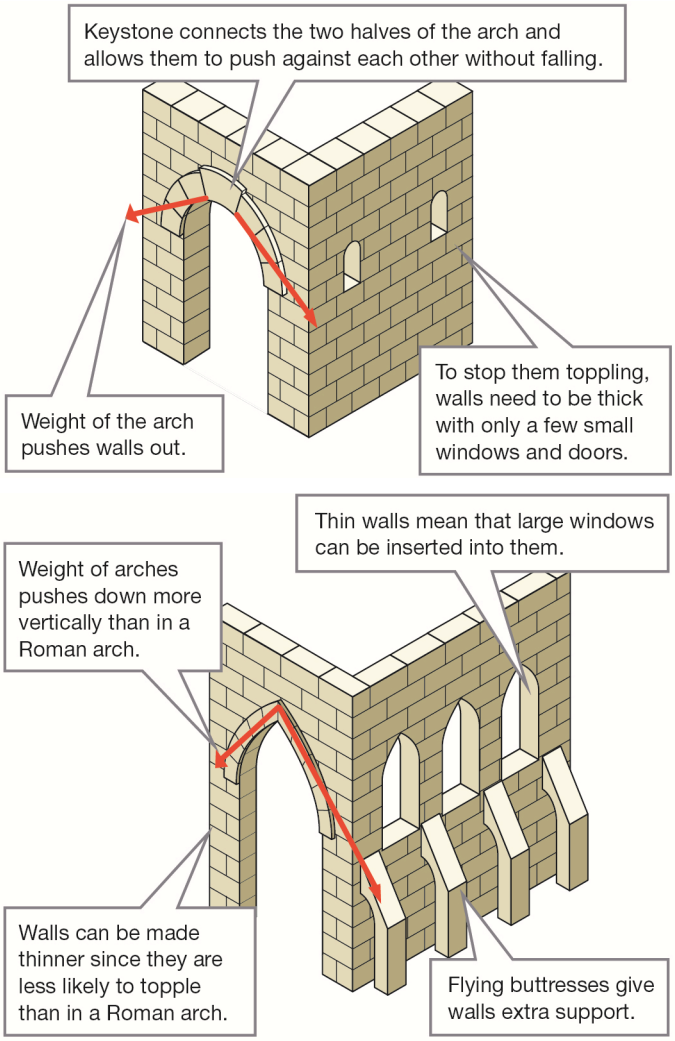
11 Diagram should show that weight forces in Gothic arches pass through the ground more steeply than in Roman arches. Diagrams should be similar to Figures 9.3.5 and 9.3.8 (see below).



12 a Compression is when two forces squash something. Tension is when two forces stretch something.

b Steel is good under both compression and tension. Concrete is only good under compression.

13 a Bowstring arch bridge

b Cantilever bridge

14 Mudbricks are easy to make and are strong under compression. The addition of grass and straw makes them perform better under tension than before. This allows them to be used for many different purposes.

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15 The force applied to your foot is the same whether you stand on broken glass or on an intact bottle. The sharp edges of broken glass have very little surface area. Stress on your skin is high and it is likely to tear or be cut. An intact bottle has a far greater surface area. Hence the stress on your skin is much lower. Your skin will remain intact.

16 Advantages: they hold a lot of people; public transport to the tower provides service to a lot of people; water, electricity and gas supply is all delivered to one location, views.

Disadvantages: expensive and difficult to build; limited sense of community; difficulty in getting up and down; no open space; emergency exit is difficult.

17 The antennae of Willis Tower are 'add-ons'. The spires on top of Petronas are part of the design of the building.

18 No-one wanted to climb all the stairs of taller buildings. Reliable lifts and a reliable electricity supply to service them were required before higher towers could be built.

19 Heat rises. Hence, warm air moves up a skyscraper, especially if any windows are open. This creates strong winds every time the ground floor doors are opened. Revolving doors block this airflow without blocking people.

20 Children have a far lower centre of mass than adults. This makes them far more stable than adults too, particularly in sports such as skiing.

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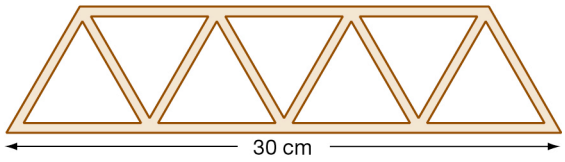
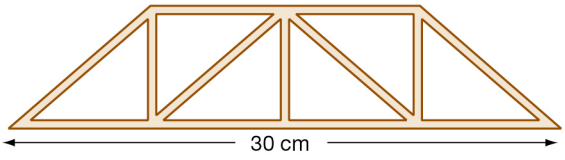
21 Diagram should be similar to one or all of the trusses in Figure 9.3.17 (see below).

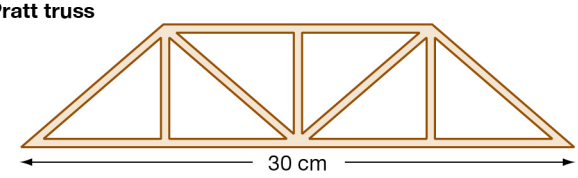
Warren truss



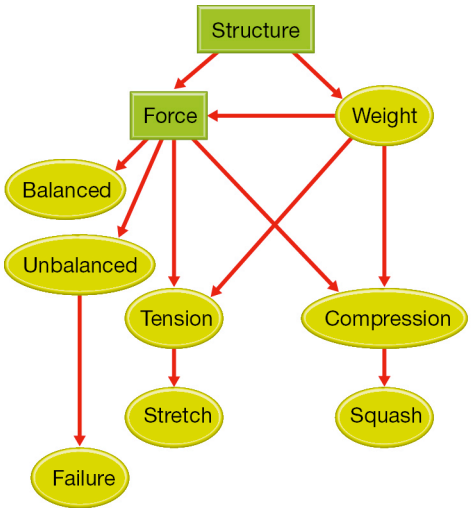
Howe truss



Pratt truss



22 Diagrammatic answer (see below)



Thinking scientifically

Q1 A

Q2 C

Q3 B

Q4 C

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Chapter 10: Forensic science

Unit 10.1

1 Sweat, oils and amino acids

2 **a** Black carbon powder

b White aluminium powder

c Ninhydrin

3 Fibres and fluff from their own clothes, flakes of skin/dandruff, hair, and smears of body oil and sweat.

4 Every piece of evidence is important and provides another clue as to what happened, who did it and why. Some pieces are trace evidence and are therefore microscopic. Hence the CSU ensures that every piece of evidence is collected.

5 **a** Various answers possible. Some signs that could be mentioned are:

- colour of banana, going from green to yellow to black spots to all black
- smell, going from little smell to sweet smell to sweet but stronger and 'cloying' smell
- firmness, going from hard to soft to extremely soft to pulp.

b All things change when they die, whether they are corpses or bananas. Each organism has its own characteristic timeline of changes. These can be used to determine when the banana was picked or when the person was killed.

6 **a** 37°C

b Temperature usually drops about 0.8°C per hour after death.

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c Tabulated answer (see below)

Time (h)	Temp. (°C)	Time (h)	Temp. (°C)	Time (h)	Temp. (°C)
0	37	9	29.8	18	22.6
1	36.2	10	29.0	19	21.8
2	35.4	11	28.2	20	21.0
3	34.6	12	27.4	21	20.2
4	33.8	13	26.6	22	19.4
5	33.0	14	25.8	23	18.6
6	32.2	15	25.0	24	17.8
7	31.4	16	24.2		
8	30.6	17	23.4		

7 Fibres are circumstantial evidence since they point to a suspect being there but cannot prove it. This is because many people have the same shirt, jeans or dress. Likewise, lots of people have the same colour and type of hair.

8 Crime scene A: Broken mirror, shards of mirror on couch, fabric caught in window glass, broken window, five shards of glass on floor, clock, footprints, hammer on floor, yellow folder on floor, book open but OK, no rips in wallpaper, flowers OK, lots of smaller flowers, lots of water on coffee table, white ‘shine’ on overturned vase on coffee table, plain plate, clean lampshade, no cushion, overturned chair has thick legs.

Crime scene B: Mirror is intact, no shards of mirror on couch, blood on window glass, broken window but remaining glass has different shape, seven shards of glass on floor, no clock, no footprints, jemmy bar on floor, no yellow folder on floor, book has ripped pages, ripped wallpaper, one flower broken, fewer, larger flowers, less water on coffee table, no ‘shine’ on overturned vase, patterned plate, dirty lampshade, cushion, overturned chair has thin legs.

9 Similarities: All negative impressions (i.e. the opposite of the actual track on the shoes); all can be used to identify the type/model of shoe and any characteristics like scuffing, cuts or stones in their track

Differences: Impressions will be lost quickly from dry concrete as the water forming the impression evaporates while the other impressions will stay for far longer (assuming the snow does not melt)

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10 **a** Trace

b Physical

c Trace

11 **a** As you run forwards, pressure will be more on the front of the foot than the back. Hence the track will be deeper there.

b As you run backwards, pressure will be more on the back of the foot.

c As you turn quickly, sideways pressure will push the sand a little deeper and make a 'wall' of sand opposite the direction you are turning.

12 Clothes fabric is very porous and will absorb much of the sweat and oils that a fingerprint leaves behind. Also, fabric twists and moves and is made of individual fibres. All this will tend to smudge any fingerprint that is left there.

13 **a** Broken furniture indicates that a struggle or fight probably happened.

b Only a few smudged fingerprints indicates that the criminal is likely to have 'wiped over' the crime scene to remove them.

14 **a** The suspect on the right

b The suspect on the right has characteristic features that make him memorable, whereas the suspect on the left has few distinguishing or memorable features.

15 CSU teams only want to collect the trace evidence left by the victim(s) and criminal(s). They don't want to collect their own hairs, dandruff, skin flakes, body oil etc. This would compromise the investigation. Gloves, masks and full body suits stop this happening.

16 **a** Various answers possible.

i Students should at least mention sex/gender, hair colour and rough age.

ii Students should at least mention what they had for breakfast and how they got to school (car, walk, bike etc.).

iii Students should at least mention its make and colour.

iv Students should at least mention the room number.

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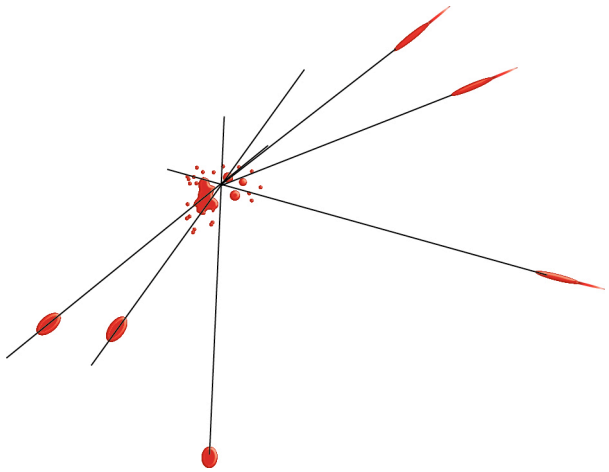
17 Diagrammatic answer (see below)



Unit 10.2

1 Diatoms inside the stomach of a drowning victim. Seeds on a body from plants not in the area where the body was found.

2 10–50 metres

3 The style will generally indicate whether they were worn by a man or a woman and will give some idea as to the fashion era they came from.

4 A body found in a burnt-out house probably lived there. It is easy to find out who owned or rented the property and identify the body. Unless a body found in the bush has personal identification on it (e.g. driver's licence), it could belong to any one of hundreds of missing people. Identification is therefore more difficult.

5 **a** That a particular person was there

b When the person was there or why

6 **a** Hair and toothbrushes are full of a person's DNA and so can be used to identify them.

b The DNA from relatives will be similar to those of the body.

7 A close shotgun blast will produce one wound. From far away, the pellets will cause a pattern of wounds (peppering).

8 A video of the Ford Falcon ute was posted on Facebook in 2009. This was used by police as evidence of unsafe driving, leading to successful conviction of the driver and confiscation of the car.

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9 If his exposure was accidental, then the alpha rays from polonium-210 would have been blocked by the skin and not entered his blood and tissues. Hence, the polonium had to be injected or swallowed, perhaps in food or a drink.

10 **a** Suspect D

b Victim

11 **a** Bullets

b Shotgun from a distance

c Poison

12 **a** To prevent shoplifting and identify shoplifters

b To prevent robbery and identify criminals

c To prevent people driving off without paying and to identify the number plates of their cars

13 Various answers possible. Possible views for include:

- increases detection of criminals and hence increases public security
- allows police to intervene or make their presence known before a crime is actually committed. Hence less crime and less court time and expense.

Possible views against include:

- loss of privacy
- government and police could potentially monitor people for other reasons (e.g. political views).

14 Mobile phone records show where each call was made and where it called but not who made the call. A mobile phone therefore can be left with someone else to make a call at the time of the crime.

15 **a** YouTube provides a wide and immediate audience for people, while earlier technologies did not.

b Various answers possible. Possible responses:

- A dangerous activity might also be against the law. If it is on YouTube, then it can be used by police to identify and prosecute the people doing it.

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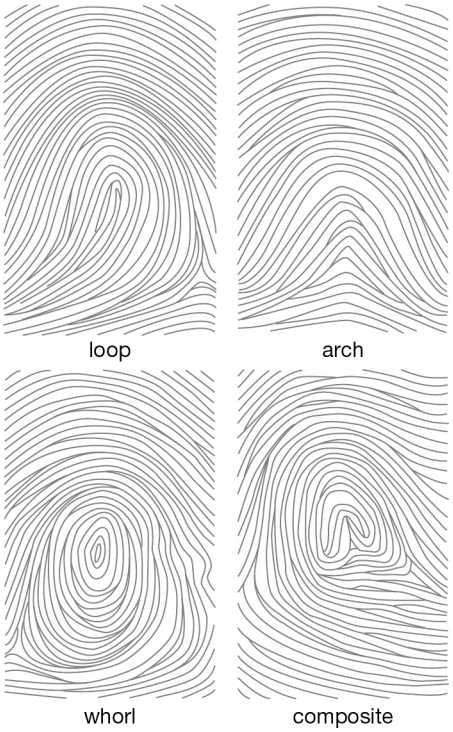
- If someone gets hurt, then the video can be used by them or their family to identify and prosecute the others in the video for criminal damage, medical expenses etc.

16 The fact that they were poisoned will often be only found out after an autopsy. This gives the assassin time to get away and makes it less likely they will be detected as the killer.

17 Diagrammatic answer (see below).



Unit 10.3

1 **a** To gain money, through deception, passing themselves off as someone else

b To get through security, to get through immigration and customs or access to secure buildings

c To gain sensitive information on computers or to access computer systems so that they can be changed.

2 **a** The coloured ring visible at the front of the eye.

b The interior lining at the back of the eye.

3 266

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4 **a** iii **b** iv

c ii **d** i

5
- Notes with identical serial numbers
- The material the note is made of
- No holograms or windows (difficult to reproduce)
- Smudged text
- Unusual colours
- No watermark or metal bands (in foreign paper banknotes)

6 Chromatography

7 ePassports hold all the information about the holder and a photo of them in their electronic chip. This information cannot be changed or faked. Normal passports potentially can have their information and photo changed.

8 **a** To allow them (and only them) to access important, sensitive criminal files.

b To identify patrons who will not cause trouble, to allow them easy access to the club and to provide them with VIP treatment.

9 Criminals could steal paper licences and pretend to be the licence holder. This helped them access bank accounts and commit crimes without anyone knowing who they actually were.

10 Suspect B's pen

11 The iris and retina have more points of identification than fingerprints, making them harder to fake.

12 Various answers possible. Each student will construct their letters differently.

13 The microchip stores information that allows dogs and cats to be returned to their owners if lost. The tattoo alerts authorities to the existence of a microchip.

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14 a Possible advantages include:

- tracking babies and ensuring that they go home with the right parents
- recording and updating medical records so that correct medical care can always be given
- avoiding identity fraud
- replacing passports, PINs, passwords etc.

b Possible disadvantages include:

- loss of privacy of information
- difficulty in getting insurance etc. because all medical files and personal information is on the chip
- police, government and authorities can potentially track what you do and where you go
- businesses might use the information to target you for future sales.

c Student response.

d Student response.

15 Various answers possible. Each student will construct their letters differently.

Chapter review

1 The terrorist attacks of 11 September 2001 ('9/11')

2
- They last longer (about six times).
- They are harder to counterfeit.

3 Name, sex, nationality and date of birth and a digital version of a photograph of the passport holder

4 a Murder or manslaughter of another human

b Deliberate fire

c Study of guns, bullets and their paths

d A dead body

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e Measurements of the human body to determine height, sex etc.

f Murder for political reasons

g Fake

h Glows under certain lights (e.g. UV)

5 The placement (and orientation) of each piece of evidence can provide investigators with as much information as the evidence itself.

6 Each person's DNA is unique. No two people have identical DNA.

7 An involuntary process in which a person merges new images (and memories) with old ones. Exposure to many images can change the idea of what a person looked like, making identification unreliable.

8 You only delete its access route. The material is still there.

9 Your bedding has stray hairs, dandruff, body oils, sweat and dead skin. Your brush/comb and toothbrush will contain large traces of hair, dandruff and saliva.

10 a Normal (living) body temperature is 37°C. Temperature drops by about 0.8°C per hour. 35°C indicates a 2°C drop. Hence, 2 ÷ 0.8 = 2.5 hours.

b 29°C indicates a 8°C drop. Hence, 8 ÷ 0.8 = 10 hours.

c 17°C indicates a 20°C drop. Hence, 20 ÷ 0.8 = 25 hours (about 1 day).

11 Physical evidence is evidence that is easily seen, measured and compared. It can also be cleaned up. Trace evidence is evidence that is microscopic. Hence it cannot be completely cleaned up.

12 a Composite

b Arch

c Loop

d Whorl

13 a The stomach and lungs would have been full of water.

b Investigators could compare the diatoms in the stomach with those from every pond, lake and stream near where the body was found. A match in diatom shape would then indicate the body of water in which the person drowned.

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14 Various rankings possible but a most likely ranking of most to least useful is:

- driver's licence (will have complete name, date of birth and address)
- the body is male (vital information for a known or unknown body)
- dark birthmark (people will recognise him by this)
- pins in left ankle (will be on file at a hospital)
- dental fillings (will be on file at a dentist)
- tattoo (may be recognised, no files kept at tattooists)
- leather jacket (may be recognised).

15 Ricin is rare and produces symptoms similar to other diseases.

16
- Whether the patron has a criminal background
- Whether the patron has caused problems in the past
- Whether the patron has had financial difficulties
- Home address and contact in case of emergency

17 a Possible advantages include:

- allows for easy and accurate identification of bodies and suspects
- passports, driver's licenses, Medicare cards etc. could be replaced by the one card containing your autoradiogram
- minimises identify fraud since access to banks, credit, pensions etc. might be via autoradiogram only (like a barcode)
- all information can be linked to your autoradiogram (e.g. medical records, criminal records).

Possible disadvantages include:

- loss of privacy
- expense of setting up and maintaining the scheme
- uncertainty of who would have access to the data
- possibility of extortion, threats and blackmail because of the data.

b Student response.

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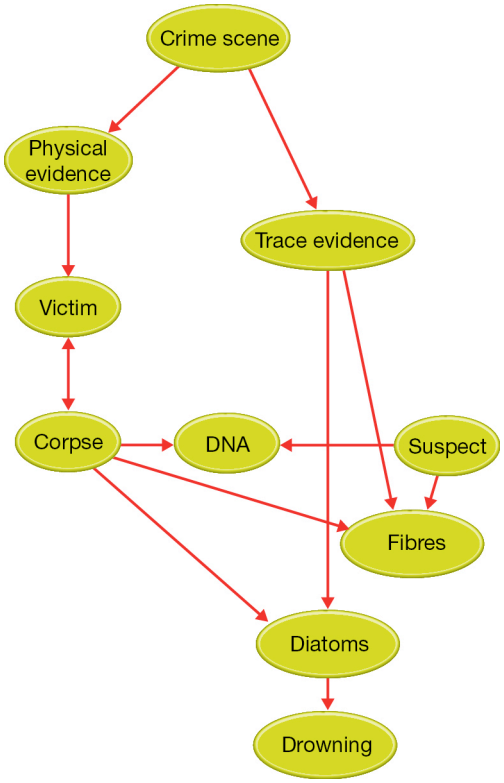
18 Diagrammatic answer (see below)



Thinking scientifically

Q1 C

Q2 B

Q3 B

Q4 C

Q5 A

Q6 B and D

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