Exam-style questions and sample answers have been written by the authors. In examinations, the way marks are awarded may be different.

Coursebook answers

Chapter 1

Getting started

1 excretion, sensitivity, growth, reproduction, movement, nutrition, respiration

2 See Topic 1.1 for full descriptions of each term. Learners are not likely to be able to describe each one correctly at this stage. Their answers will provide you with an opportunity to pick up any misconceptions.

Science in context: The puzzle of the platypus

There are no 'correct' answers to these discussion questions. Learners may suggest these ideas, or you could use them to prompt discussion:

1 Using the same two-word name means that scientists all over the world can be sure they are talking about the same organism, no matter what language they speak. Some learners may say it is not a good idea – for example, because these names look 'scary' and unfamiliar, so may put some people off learning about different organisms.

2 In the 18th century, Latin was the language of education in Europe. In some ways, it is not a bad idea to use a language that no one speaks now, as it avoids confusion. If we used English or Spanish or Mandarin, then people speaking those languages might get mixed up between common names and Latin names. But the names can be a bit difficult to deal with for many people.

Questions

1 Yaks belong to the genus *Bos* and the species *Bos grunniens*.

2 To belong to the same species, organisms should be able to reproduce to produce fertile offspring, but yakolos are infertile.

3 a Sea anemones do not obviously move. Their tentacles perhaps look like flower petals.

b You would see that their cells do not have cell walls, and never contain chloroplasts.

4 With a microscope, you could see that their cells would have cell walls. Some of them would also have chloroplasts containing chlorophyll.

5 a *Staphylococcus*

b the prokaryote kingdom

c Any two from: Its cell wall is not made of cellulose. It does not have a nucleus or mitochondria. It has a circular loop of DNA. It has plasmids.

6 a hypha

b The cells have cell walls.

c reproduction

7 animal kingdom

8 Amphibians have a smooth skin, but reptiles have scales. Amphibians lay eggs with no shells in water; reptiles lay eggs with soft shells on land.

Chapter 1 continued

9 **a** hair; pinnae; mammary glands

b diaphragm; sweat glands; uterus; placenta; different kinds of teeth (teeth could also be considered external features)

10 **a** jointed legs; exoskeleton

b Myriapods have jointed legs on almost all segments, but arachnids have only four pairs of jointed legs. Myriapods have one pair of antennae, but arachnids do not have antennae. Arachnids have a body divided into a cephalothorax and abdomen, but this is not so in myriapods.

11 three pairs of jointed legs; one pair of antennae; body divided into head, thorax and abdomen

12 Ferns do not have flowers, but flowering plants do.
Ferns produce spores on the backs of their leaves, but flowering plants do not.

13 Answers will depend on the plants that learners find. Features they can use for identification are: the veins on the leaves – monocots have parallel veins, but dicots have a network of veins; the flowers – monocots have flowers with parts in multiples of three, but dicots have flowers with parts in multiples of four or five.

14 The diagram shows that the virus is not made of cells. All living organisms are made of cells. Viruses are unable to carry out any of the characteristics of living organisms on their own – they do not show movement, growth, excretion, respiration, sensitivity or nutrition. However, they can reproduce, and some scientists consider that this justifies classification as a living organism. But they can only do this inside a living cell, which suggests that they cannot be considered to be alive themselves.

Exam-style questions

1 C ; **[1]**

2 D ; **[1]**

3 D ; **[1]**

4 D ; **[1]**

5 C ; **[1]**

6 **a** A *Ilex aquifolium* **[1]** ; B *Iris germanica* **[1]** ; C *Buddleia davidii* **[1]** ; D *Tricyrtis hirta* **[1]** ; E *Fraxinus excelsior* **[1]** ;

b **i** a group of organisms that can reproduce **[1]** ; to produce fertile offspring **[1]** ;

ii binomial ; **[1]**

7 **a** arthropods ; **[1]**

b P: arachnids **[1]** ; Q: insects **[1]** ; R: myriapods **[1]** ;

c two pairs of wings **[1]** ; body divided into head, thorax and abdomen **[1]** ;

8 **a** *Commiphora africana* and *Commiphora angolensis* **[1]** ; because they belong to the same genus **[1]** ;

b Any two from:

- net of veins in leaves ;
- flower parts in multiples of four or five ;
- vascular bundles in stem arranged in a ring ;
- main roots with side roots ;
- seeds with two cotyledons ; **[Max. 2]**

Chapter 1 continued

9 a prokaryote **[1]** ; and protoctist **[1]** ;

b cells with cell walls not made of cellulose **[1]** ; do not have chloroplasts **[1]** ;

c i X genetic material (accept DNA or RNA) **[1]** ; Y protein coat **[1]** ;

ii Any two from:

- only organisms are classified into kingdoms ;
- viruses are not considered to be organisms because they cannot carry out the characteristics of living things ;
- and are not made of cells ; **[Max. 2]**

Chapter 2

Getting started

1 You could look for cell walls, which all plant cells have, but no animal cell does. You could also look for chloroplasts – if the cell has these, it is a plant cell. However, if it does not have them it could still be a plant cell.

2 You could look for a nucleus. If it does not have one, it is a prokaryote.

Science in context: Cells from deep time

1 They could perhaps look for fossils, as fossil bacteria have been found that date to this age. However, it is often difficult to identify fossils of bacteria, as they have no hard parts and are very small.

2 There are many possible approaches to this question, and ideas that learners might have. There are no 'correct' answers. In some ways, bacteria have been more successful than humans – there are far more of them on Earth today than there are humans, and they continue to be very successful in terms of being able to live in every environment that has ever been investigated. However, humans have brains that allow us to be aware of our environment and change it. There is considerable capacity for wide-ranging discussion here.

Questions

1 A unicellular organism is made of a single cell – for example, bacteria, protoctists. A multicellular organism is made of many cells – for example, human, plant.

2 The animal cells do not have any coloured parts, which makes them difficult to see without a stain. The plant cells contain green chloroplasts. Their cell walls, which are much thicker than cell membranes, also stand out.

3 a ribosome

b nucleus

c chloroplast

d cell wall

e vacuole

f cell membrane

4 ribosome, nucleus, cell membrane

5 For example:

Bacterial cell	Animal cell	Plant cell
has cell membrane	has cell membrane	has cell membrane
has cell wall, but not made of cellulose	no cell wall	cell wall made of cellulose
has cytoplasm	has cytoplasm	has cytoplasm
no nucleus	has a nucleus	has a nucleus
DNA is circular	DNA is not circular and forms chromosomes	DNA is not circular and forms chromosomes
has ribosomes	has ribosomes	has ribosomes
does not have mitochondria	has mitochondria	has mitochondria
does not have chloroplasts	does not have chloroplasts	may have chloroplasts

6 1000

7 a Actual length in Figure 2.10 is 83 mm.

b 83 mm = 83 × 1000 = 83 000 µm.

c Real size = 83 000 ÷ 20 000 = 4.15 µm.

d 1 mm = 1000 µm.
So you could fit
1000 ÷ 4.15 = 240.96.
Rounded up, this is 241 mitochondria.

Chapter 2 continued

Exam-style questions

1 B ; [1]

2 C ; [1]

3 B ; [1]

4 B ; [1]

5 a i they have cell walls ; [1]

ii they have a nucleus / there are many cells together ; [1]

iii chloroplast ; [1]

b i contains DNA / chromosomes **[1]** ; which contain information about which proteins the cell makes **[1]** ;

ii site of protein synthesis **[1]** ; using instructions from (DNA in) the nucleus **[1]** ;

6 a magnification = image size ÷ actual size **[1]** ; correct substitution into equation **[1]** ; correct statement of magnification, with a × sign and no unit **[1]** ;
Width of jellyfish in the photo is 82 mm.
Actual width of jellyfish is 50 mm.
So magnification is 82 ÷ 50 = ×1.64
Round up to 2 significant figures: ×1.6

b Any three of the following pairs:

- cell membrane – partially permeable / controls what enters and leaves the cell ;
- cytoplasm – where many metabolic reactions take place ;
- nucleus – contains, DNA / chromosomes / information about which proteins the cell makes ;
- ribosome – where proteins are made ;
- mitochondrion – site of aerobic respiration / releases energy from glucose ; **[Max. 6]**

c conduction of electrical impulses ; [1]

7 a nucleus ; [1]

b Any six from:

- protein synthesis requires energy ;
- B is a mitochondrion; mitochondria provide energy (*do not accept produce energy*) ;
- by aerobic respiration; which releases energy from glucose ;
- C is a ribosome ;
- ribosomes are the site of protein synthesis ; **[Max. 6]**

Chapter 3

Getting started

- The particles are far apart and rarely collide with each other – gas
- The particles vibrate on the spot – solid
- The particles are close to one another but can move around – liquid
- The particles move freely in all directions – gas
- The particles stay in contact and slide past one another as they move – liquid
- The particles are in fixed positions, close to one another – solid

Science in context: Using diffusion to clean the blood

1 Learners cannot be expected to know any detail about transplants or availability of organs and should be encouraged to put forward any suggestions that they have. The real reasons are: the body will reject an organ that is from a person with a different tissue type, so it is very difficult to find a kidney that will be accepted by the recipient's body; there are never enough donated kidneys to go around – they need to come from a healthy person who has recently died, or from a close relative who is willing to donate one.

2 This question looks ahead to factors that affect the rate of diffusion, and to the concept of a diffusion gradient. Learners may be able to work out for themselves that keeping the fluid flowing through will make sure that the harmful substances do not build up in the dialysis fluid, and may also be able to see that this would stop the substances from diffusing out of the blood and into the fluid.

Activity 3.1

1 The 'particles'/people are spread out.

2 The 'particles'/people have diffused to fill the space available – by moving around and bumping into each other (or in this case, avoiding bumping into each other).

Questions

1 a net movement – the overall result of some particles moving one way, but more moving in the other direction

b concentration gradient – a difference in concentration between two solutions; the gradient 'slopes down' from the high concentration to the lower concentration

c random movement – movement in any direction, just by chance

2 cell membrane

3 Any three from (or other correct examples):
- oxygen gas diffusing from outside a cell to inside
- carbon dioxide gas diffusing from inside a cell to outside
- oxygen gas diffusing from inside a photosynthesising cell to outside
- carbon dioxide gas diffusing from outside a photosynthesising cell to inside
- glucose or other solutes diffusing through the cytoplasm of a cell.

4 the kinetic energy of the particles

Experimental skills 3.1

1 The cubes had an alkali in them. As the acid diffused into them, it neutralised the alkali, so the indicator changed colour.

2 The volume was the same.

3 The surface area of the four small cubes was larger than the surface area of the large cube.

4 The time taken for the four small cubes to completely change colour was smaller than the one single cube.
This is because the surface area of the small cubes was greater than for the single cube.

5 The conclusion will depend on the results but is likely to be: The greater the surface area, the faster diffusion takes place.

Chapter 3 continued

Questions

5 a At higher temperatures, particles have more kinetic energy and move faster.

b The greater the diffusion gradient, the faster the rate of diffusion. (Some learners may be able to explain this in terms of the larger number of moving particles in the area of high concentration, resulting in a greater net movement towards the area of low concentration.)

c Many small tubes have a larger surface area than a single large tube, which speeds up diffusion.

d This decreases the distance across which the particles have to travel, to get from the blood into the dialysis fluid, so it takes them less time.

6 Water is the solvent, and sugar is the solute.

7 The water molecules are small enough to get through the holes in the membrane, but the sugar molecules are too big.

8 From the dilute solution to the concentrated solution.

9 The kinetic energy of the water molecules.

10 The dilute solution has the higher water potential, because it contains more water molecules.

Experimental skills 3.3

1 Water moved by osmosis from the water into the sugar solution. (It moved from a high water potential to a lower water potential.) The sugar molecules could not move out because they were too big.

2 The answer will depend on the results. The mean can be calculated by subtracting the original height from the final height and dividing by time taken.

3 Learners may be lucky and find that the movement of water up the tube is faster when there is a greater difference between the concentrations inside and outside the dialysis tubing. However, in practice, it is extremely difficult to take the apparatus apart, thoroughly wash the tubing, refill it and reattach it, without changing numerous other variables that can also affect the results.

4 The liquid would move up the tube faster, because the surface area of the tubing would be greater, resulting in a greater rate of diffusion.

5 Use the same apparatus, with the same concentration of sugar solution each time. Use water at a range of different temperatures and measure the rate at which the liquid rises up the tube. You would expect the rate of movement to be faster at higher temperatures.

Questions

11 When an animal cell is placed in pure water, water enters the cell by osmosis through the partially permeable cell membrane.

12 Plant cells have a strong cell wall surrounding the cell membrane, which stops the cell bursting.

13
- Water moves out of the cell through the partially permeable cell membrane.
- The cytoplasm and vacuole shrink.
- The cell membrane is pulled away from the cell wall.

14 The same solution that the cell is immersed in. The only thing between the external solution and space X is the cell wall, which is fully permeable.

15 The cells will take up water by osmosis, because the water potential of the water outside the cell is greater than the water potential of the solution inside the cell. The vacuole and cytoplasm will increase in volume, so the cell membrane will be pushed back against the cell wall, into its normal position.

Chapter 3 continued

Experimental skills 3.4

1 Learners should find that they get longer.

2 Each cell in the piece of potato gained water by osmosis, because the solution inside the cell was more concentrated (had less water, or a lower water potential) than the water outside. As each cell swelled up, this increased the size of the whole strip.

3 Learners should find that they get shorter.

4 Each cell in the piece of potato lost water by osmosis, because the solution inside the cell was less concentrated (had more water, or a higher water potential) than the solution outside. As each cell lost water and shrank, this decreased the size of the whole strip.

Exam-style questions

1 C ; **[1]**

2 B ; **[1]**

3 D ; **[1]**

4 B ; **[1]**

5 B ; **[1]**

6 a diffusion **[1]** ; random movement of particles **[1]** ; down a concentration gradient **[1]** ;

b to allow time for the dye solution to come to same temperature as the water bath ; **[1]**

c Any two from:

- the concentration of the dye solution ;
- the volume of the dye solution ;
- the volume of the jelly cubes ;
- the surface area of the jelly cubes ;

[Max. 2]

d i the value at 20 °C, time 4.5 minutes **[1]** ; because the time is shorter than the time at 30 °C **[1]** ;

ii As the temperature increases, the time to change colour decreases. **[1]** ;

iii at higher temperatures, kinetic energy of particles increases **[1]** ; so, particles move faster / diffusion happens faster **[1]** ;

7 a

- the net movement of water molecules **[1]** ;
- from a higher water potential to a lower water potential / down a water potential gradient **[1]** ;
- through a partially permeable membrane **[1]** ;

b Any six from:

- both take up water by osmosis ;
- because there is a water potential gradient from outside the cell to inside ;
- the volumes of both cells increase ;
- the animal cell bursts but the plant cell does not ;
- because the plant cell has a cell wall (but the animal cell does not) ;
- the plant cell becomes turgid ;
- as the contents of the cell push outwards on the cell wall ;
- which is called turgor pressure ;

[Max. 6]

8 a more potassium in the plant cells than in the water **[1]** ; more sodium in the water than in the plant cells **[1]** ; use of comparative figures **[1]** ;

b active transport **[1]** ; if diffusion then concentrations in the cells and the water would be the same **[1]** ;

c Any four from:

- cells are using energy;
- from respiration ;
- to move potassium ions into the cell / move sodium ions out of the cell ;
- against their concentration gradients ;
- reference to transport proteins ;

[Max. 4]

Chapter 4

Getting started

1 a O_2

b molecule

c an element

2 a carbon, hydrogen and oxygen

b $C_6H_{12}O_6$

c a compound

Science in context: How did life on Earth start?

These questions are for interest and discussion only – there are no 'right' answers.

1 The conditions are not right – there is a different mix of chemicals in the atmosphere and the oceans. This is a big and very wide topic, and some learners might like to research further into modern theories about the origin of life.

2 Learners will probably first think of dangers that Martian life might cause to humans, but there is very unlikely to be an issue with this. It is more important that, if we are going to try to find traces of past life on Mars, we do not contaminate it with traces of life from Earth. Discussions could consider how we can avoid this.

Questions

1 Similarities: both are made of C, H and O only; both are made of many glucose molecules combined to form long chains
Difference: cellulose molecules lie straight, but starch molecules coil into a spiral shape

2 glucose

Experimental skills 4.1

1 Answers will depend on the foods that learners tested.

2 Learners should find that all the foods containing starch and reducing sugar are of plant origin. If they are processed foods with several ingredients, then at least some of these ingredients will have come from plants.

Activity 4.1

Learners should consider the variables that they need to standardise. In particular, they must use the same mass of food to test, mix it with the same volume of water, add the same volume of Benedict's solution and heat them to the same temperature (preferably in the same water bath at the same time). They may also say that the dimensions of the test tube should be the same, as this will affect heat transfer from the water bath to the mixture inside the tube. They would then time how long it takes for the first colour change. As this is difficult to judge, they might suggest having a reference tube with a colour that they can match their experimental tubes against.

If time allows, you could provide learners with two glucose solutions of different concentrations and let them try out their planned experiment. This is always a good way of helping them to see any weaknesses in their plans.

Questions

3 The fat layer acts as an insulator. It reduces heat loss from the animal's body to its environment.

4 Birds don't want to carry any more weight than necessary, or they would waste a lot of energy when they fly long distances. Storing energy in fat allows them to keep their weight much lower than if they stored it as carbohydrate.

5 nitrogen

6 It is not soluble. Keratin is found in hair and nails, and these do not dissolve when we are in the shower or go swimming.

Exam-style questions

1 B ; [1]

2 C ; [1]

3 B ; [1]

4 A ; [1]

5 C ; [1]

Chapter 4 continued

6 a starch and cellulose ; **[1]**

b carbon, hydrogen and oxygen ; **[1]**

c made up of many glucose molecules **[1]** ; joined in a long chain **[1]** ;

d add Benedict's solution to the liquid **[1]** ; heat **[1]** ; colour change from blue to green / yellow / orange / red indicates glucose **[1]** ;

7 a i The mixture should not be heated. ; **[1]**

ii The colour change is from blue to purple or violet. ; **[1]**

b i crush the food **[1]** ; mix with ethanol **[1]** ; pour some of the ethanol into distilled water **[1]** ;

ii a milky emulsion ; **[1]**

8 Any six from:

- measure a specific volume of DCPIP ;
- add fresh lemon juice, drop by drop / using a burette ;
- record the quantity of juice needed to make the DCPIP lose its colour; detail, e.g. swirling the mixture ;
- repeat with the other juice; using the same volume of DCPIP ;
- the juice that needs the fewer drops / smaller volume to decolourise the DCPIP has the higher concentration of vitamin C ; **[Max. 6]**

9 a 30% **[1]** ; A always pairs with T **[1]** ;

b 20% **[1]** ; if 30% is A and 30% is T, the remaining 40% is C and G **[1]** ;

c determines which proteins are made in the cell **[1]**; the sequence of bases in DNA **[1]** ; determines the sequence of amino acids in proteins **[1]** ;

Chapter 5

Getting started

The incorrect statements are:

- *In a chemical reaction, atoms of one element are rearranged to make atoms of other elements.* This is incorrect, because atoms do not change in a chemical reaction. Atoms can be arranged to make new compounds, or new substances, but not new atoms.
- *Products are changed to reactants.* This is the wrong way round – reactants are changed to products.

Science in context: Lactose intolerance

1 Making proteins, such as enzymes, uses energy and materials (amino acids). In the past, most people did not drink milk or eat dairy products as adults, so there was no advantage in being able to digest lactose. It is only since farming began, and people started to keep cows and goats to produce milk, that dairy products became part of some people's diets. Learners who are interested in this will be able to find more information on the internet. The ability to digest lactose is the result of a mutation, thought to have happened about 10 000 years ago, that has spread throughout European populations. This may be because the long, cold winters made it difficult to find fresh food, and having cattle that could supply milk throughout the winter helped people to stay alive.

2 Lactose in the solution inside the alimentary canal increases the concentration of the solution (decreases its water potential). The contents of the cells lining the canal have a lower concentration (higher water potential) so water passes out of the cells, through their partially permeable membranes, by osmosis (down the water potential gradient). The extra water in the alimentary canal causes diarrhoea.

Questions

1 *Biological* because they are made by organisms. *Catalysts* because they increase the rate of chemical reactions.

2 **a** carbohydrase

b lactose

3 As temperature increases from 0 to 37 °C, the rate of reaction increases. The increase is exponential. As temperature increases above 37 °C, the rate of reaction decreases and reaches 0 at 58 °C. This decrease is steeper than the increase at lower temperatures.

4 **a** 2

b 7

c between pH 5.6 and 10.4

Experimental skills 5.1

1 $$\text{hydrogen peroxide} \xrightarrow{\textit{catalase}} \text{water + oxygen}$$

2 There was catalase on the filter paper, because it had been dipped into the celery extract. When the paper was put into the hydrogen peroxide solution, the catalase made the hydrogen peroxide break down, releasing oxygen. The oxygen collected as bubbles on the paper, which made it rise upwards.

3, 4 and 5 These answers depend on the learners' results.

6 The experiment could be done again, this time using a range of pH values clustered around the value that gave the fastest times in this experiment.

Chapter 5 continued

7 Answers will depend on learners' experience as they did the experiment. They are likely to include:

- variables other than pH affecting the time for the paper to rise to the top – for example, differences in how much celery extract was absorbed onto the paper; differences in the sizes of the pieces of paper; differences in how the paper behaved (it might have flipped round sideways or hit the side of the tube on its way up); these are all very difficult to standardise, and learners may suggest a different method of measuring how much oxygen is released, such as collecting in a gas syringe and measuring the volume collected
- difficulty in measuring the time precisely. It is difficult to improve this, as it is almost impossible to standardise the moment at which the paper is placed at the bottom of the beaker, and also exactly when it reaches the surface of the liquid.

Experimental skills 5.2

1 It was alkaline, and the indicator (thymolphthalein) is blue in alkaline conditions. (Learners may also explain that it is alkaline because sodium carbonate has been added to it.)

2 Lipase digested the fat in the milk, breaking it down to fatty acids. These are acidic, and so they reduced the pH. This causes the indicator to change from blue to colourless.

3 and 4 These answers will depend on the learners' results.

5 The colour change does not take place instantaneously. It is impossible to judge precisely when the colour change occurs. It is tricky even to judge this to the nearest second, and it certainly cannot be done to the nearest 0.1 or 0.01 s.

6 This will depend on what the learner experienced as they did the experiment. The most likely suggestions for sources or error and improvements are:

- difficulty in deciding on the time of colour change – it would help to have a set of tubes with different pH values and the indicator, for reference
- difficulty in measuring volumes of liquids accurately – syringes and measuring cylinders could be replaced by graduated pipettes
- the possibility of unrecognised anomalous results – the chance of this could be reduced by having replicates, perhaps three at each temperature.

Questions

5 Explanations should refer to:

- the increase in kinetic energy of enzyme and substrate molecules as temperature increases
- therefore, an increase in the frequency of collisions
- the loss of shape of the active site of the enzyme as temperature increases above optimum, so that the substrate no longer fits into it
- use of the term *denaturation*.

6 Explanations should refer to:

- the active site of the enzyme only having its 'correct' shape within a narrow range around pH 7
- the loss of shape of the active site of the enzyme as pH decreases or increases from the optimum, so that the substrate no longer fits into it
- use of the term *denaturation*.

Chapter 5 continued

Exam-style questions

1 A ; [1]

2 A ; [1]

3 B ; [1]

4 A ; [1]

5 a Enzymes are proteins **[1]** ; that function as biological catalysts **[1]**. ; They are involved in all metabolic reactions **[1]**. ;
The part of an enzyme where a substrate binds is called its active site **[1]**. ; The shape of this site, and the shape of the substrate, are complementary **[1]**. ;

b they increase the reaction rate (of metabolic reactions) **[1]** ; so that these work well enough to sustain life **[1]** ;

6 C ; [1]

7 a the iodine went blue-black at the start because the solution contained starch **[1]** ; it stayed brown after adding amylase because the solution did not contain starch **[1]** ; because it had been broken down by amylase **[1]** ;

b i amylase works most quickly at pH 7 / its optimum is pH 7 **[1]** ; 4 minutes is the shortest time **[1]** ; it does not work at all at pH 4 or 11 **[1]** ;

ii Any three from:

- the concentration of amylase solution ;
- the concentration of starch solution ;
- the volume of amylase solution ;
- the temperature ; **[Max. 3]**

8 a Any five from:

- the optimum temperature of enzyme B is higher than enzyme A ;
- lowest temperature at which activity begins is higher for B than A ;
- highest temperature at which activity ends is higher for B than A ;
- figures quoted for both (e.g. optimum is 70 °C for B and 40 °C for A) ;
- for both, increase in temperature below optimum causes an exponential increase in activity ;
- for both, increase in temperature above optimum causes a steeper decrease in activity ; **[Max. 5]**

b i Any three from:

- kinetic energy of enzyme and substrate molecules increases as temperature increases ;
- so the frequency of collisions increases ;
- frequency of formation of enzyme–substrate complexes increases ;
- so, rate of reaction increases ; **[Max. 3]**

ii Any four from:

- enzyme molecule begins to lose its shape ;
- enzyme is denatured ;
- so active site no longer complementary shape to substrate ;
- enzyme–substrate complexes cannot form ;
- so, rate of reaction decreases ; idea that increasing temperature over this range results in a greater degree of denaturation ; **[Max. 4]**

Chapter 6

Getting started

1 carbohydrates and fats (and occasionally proteins)

2 sunlight

3 through photosynthesis in plants; they use energy from sunlight to make carbohydrates

Science in context: Using solar energy to make fuels

1 Ideas could include:
- reduced combustion of fossil fuels, which release long-stored carbon into the atmosphere as carbon dioxide
- use of carbon dioxide from the atmosphere for photosynthesis; this will be released again when the fuel is burnt, but overall what is released should match what has been used.

2 Accept any sensible ideas. For example, growing crops for biofuels uses large areas of land, which leads to damage to ecosystems and loss of habitats. Learners may also suggest that biofuels may need to be transported over long distances, which can be costly in terms of energy used and carbon dioxide released. They may also suggest that biofuels are not very 'energy dense'. Artificial photosynthesis could be done under controlled conditions, generating a lot of fuel in a relatively small space – this could perhaps be next to facilities that actually use the fuel (such as electricity generating stations).

Questions

1 Animals get all of their energy from organic substances, which they are not able to synthesise themselves. Plants synthesise organic substances from inorganic ones, using sunlight as an energy source.

2 Chlorophyll absorbs energy from sunlight. (*Do not accept 'attracts sunlight'.*) The energy enables carbon dioxide and water to react to produce carbohydrates.

3 two

Activity 6.1

1 The model shows that six molecules of carbon dioxide and six molecules of water produce one molecule of glucose and six molecules of oxygen.

2 Accept any sensible suggestions. For example, some pieces of orange card could be used to represent energy in sunlight, and a learner could hand some to the learners who are building the glucose molecule. The cards can be placed in the carton with the glucose molecule, showing that the energy is incorporated into it.

3 The oxygen that is released in photosynthesis comes from water molecules, not carbon dioxide. All the carbon and oxygen in the carbon dioxide becomes part of the glucose molecule.

Questions

4 Starch is a storage material, and if you are storing something you need to be able to get it back again when required. Plants need to be able to break down starch to glucose, so that they can use it in respiration to provide energy. Cellulose, however, is a structural material, used to make cell walls. It needs to stay there, not be broken down, or the cell walls would easily break apart.

5 glycogen

6 Not all parts are exposed to light (e.g. roots) and not all parts have chloroplasts (e.g. flowers) so they cannot photosynthesise and make their own carbohydrates.

7

Element	nitrogen	magnesium
Mineral salt	nitrate ions	magnesium ions
Why needed	to make amino acids, and then proteins	to make chlorophyll
Deficiency	weak growth, yellow leaves	yellowing of leaves, often especially between the veins

Chapter 6 continued

8 (Learners may differ in the knowledge they already have about plant reproduction; this is covered in more detail in Chapter 14.) Pollination is essential for sexual reproduction in plants. Nectar attracts insects to the flower, and the insects transfer pollen to another flower, allowing fertilisation to take place.

9 a captures more energy from sunlight; increases the rate of diffusion of carbon dioxide into the leaf

b allows sunlight to penetrate to all tissues in the leaf; reduces the diffusion distance for carbon dioxide

10 It has a large number of chloroplasts, where photosynthesis takes place.
This means that there is a lot of chlorophyll, which transfers energy from sunlight to energy in carbohydrates.
The cells are tall and thin, so many can be packed into a small area, with few cell walls for sunlight to pass through to reach all of the chloroplasts.

11 They receive less sunlight than other tissues in the leaf.

12 The electron micrograph has better resolution (the image is sharper). It provides a three-dimensional image, whereas the light micrograph is in two dimensions.

Experimental skills 6.1

1 They should find that the leaf becomes blue-black, indicating that it contains starch.

2 Boiling breaks down cell membranes. This is necessary because there are membranes around the chloroplasts and around the cell which need to be broken down to allow the iodine to come into contact with the starch, which is inside the chloroplasts inside the leaf cells.

3 to allow any change in colour to be seen more clearly

Experimental skills 6.2

1 They should find that only the green parts contained starch.

2 Chlorophyll is needed for photosynthesis.

Experimental skills 6.3

1 If the plant was not destarched, we would not know whether any starch we found had been made during the experiment or before.

2 To give the plant time to photosynthesise and make starch.

3 Light is necessary for photosynthesis.

Experimental skills 6.4

1 Either leaf could be said to be the control. One has carbon dioxide and one does not; it is justifiable to say that either one is the experiment, and the other is the control. The essential point is that you need both, in order to compare the results.

2 This was to control a variable. The only difference between the two flasks is that one has a liquid that absorbs carbon dioxide, and the other has a liquid that does not.

3 Carbon dioxide is necessary for photosynthesis.

Experimental skills 6.5

1 The plant releases oxygen as bubbles, which we can see and count.

2 As light intensity increases, the rate of photosynthesis increases.

3 The heat shield prevents temperature becoming an uncontrolled variable.

4 The bubbles released may not all be the same size. It is also not easy to count them reliably. Measuring volume will give a more reliable indication of the quantity of oxygen released.

Chapter 6 continued

Experimental skills 6.6

1 Look for these features on the line graph:

- independent variable (temperature or mass of sodium hydrogencarbonate added) on the *x*-axis
- dependent variable (number of bubbles per minute) on the *y*-axis
- good scales on both axes, going up in sensible and regular intervals, and using at least half of the grid provided
- points plotted accurately, as neat crosses
- lines drawn with a ruler between points

2, 3 and 4 These answers will depend on the learner's results, and their experience in carrying out their planned investigation.

Experimental skills 6.7

1 Learners should obtain these results:
tube in the dark with no plant: orange-red, a little carbon dioxide
tube in the dark with a plant: yellow, a lot of carbon dioxide
tube in the light with no plant: orange-red, a little carbon dioxide
tube in the light with a plant: purple, no carbon dioxide

2 tube in the dark with no plant: There was nothing to alter the concentration of carbon dioxide in the liquid, so it remained the same colour that it started.
tube in the dark with a plant: The plant respired, releasing carbon dioxide.
tube in the light with no plant; There was nothing to alter the concentration of carbon dioxide in the liquid, so it remained the same colour that it started.
tube in the light with a plant: The plant photosynthesised at a greater rate than it respired, using up the carbon dioxide in the tube.

Questions

13 It is likely that learners used an *x*-axis scale showing distance of the lamp from the beaker. This means that, as you go from left to right on their graph, light intensity *decreases*. This contrasts with the graph in Figure 6.23, where light intensity *increases* from left to right. Their curve is therefore likely to be a mirror image of Figure 6.23.
There may also be other differences, depending on the learner's results.

14 Between 0% and about 0.12%, because over this range the rate of photosynthesis increases as the carbon dioxide concentration increases.

Exam-style questions

1 D ; **[1]**

2 B ; **[1]**

3 D ; **[1]**

4 A ; **[1]**

5 D ; **[1]**

6 a i palisade mesophyll ; **[1]**

ii Any three from:

- cells contain many chloroplasts ;
- in which photosynthesis takes place ;
- (chloroplasts) contain a lot of chlorophyll ;
- which transfers energy from light to energy in carbohydrates ;
- cells are tall and narrow ;
- allowing sunlight to reach chloroplasts without having to pass through many cell walls ; **[Max. 3]**

b Any two from: B ; E ; I ; (do not allow A, F or H, as these are not cells or tissues). **[Max. 2]**

Chapter 6 continued

c it can change shape **[1]** ; to open or close the stoma **[1]** ;

d water moves up through the xylem vessels in structure E **[1]** ; then into a palisade cell in layer C and into a chloroplast **[1]** ;

7 a for photosynthesis **[1]** ; idea that photosynthesis takes place inside chloroplasts **[1]** ;

b A **[1]** ; it does not contain any chloroplasts **[1]** ;

c B ; **[1]**

d Any two from:

- it absorbs energy from light (do not allow 'attracts') ;
- the energy is used to make carbon dioxide and water react together ;
- chlorophyll transfers energy from sunlight to energy in carbohydrates ;

[Max. 2]

8 a carbon dioxide and water **[1]** ; react to produce glucose and oxygen **[1]** ; using energy from sunlight **[1]** ; absorbed by chlorophyll **[1]** ;

b Any two of these pairs:

- glucose – used to release energy in respiration ;
- starch – as an energy store ;
- cellulose – to make cell walls ;
- sucrose – for transport ;
- nectar – to attract pollinators to flowers ;

[Max. 4]

9 a as temperature increases, rate of photosynthesis increases up to 25 °C **[1]** ; and then decreases **[1]** ; idea that decrease in rate after maximum is steeper than increase in rate before maximum **[1]** ; any correct quote of a change between two values, quoting both temperature in °C and volume of oxygen released per minute (units must be given) **[1]** ;

b curve with more carbon dioxide is above the curve for normal air **[1]** ; because in normal air carbon dioxide concentration is a limiting factor **[1]** ; so providing more carbon dioxide allows the plant to photosynthesise faster **[1]** ;

c idea that the optimum temperature depends on enzymes **[1]** ; enzymes are not affected by carbon dioxide concentration / enzymes in both carbon dioxide concentrations begin to be denatured at the same temperature **[1]** ;

d Any three from:

- enzyme molecules denature and the active sites lose their shape ;
- so can no longer form enzyme–substrate complexes ;
- so, no products are formed ;
- idea that the degree to which shape is lost increases with increasing temperature ;

[Max. 3]

10 a independent variable is percentage concentration of sodium hydrogencarbonate / carbon dioxide concentration **[1]** ; dependent variable is distance moved by meniscus after 30 minutes / rate of photosynthesis **[1]** ;

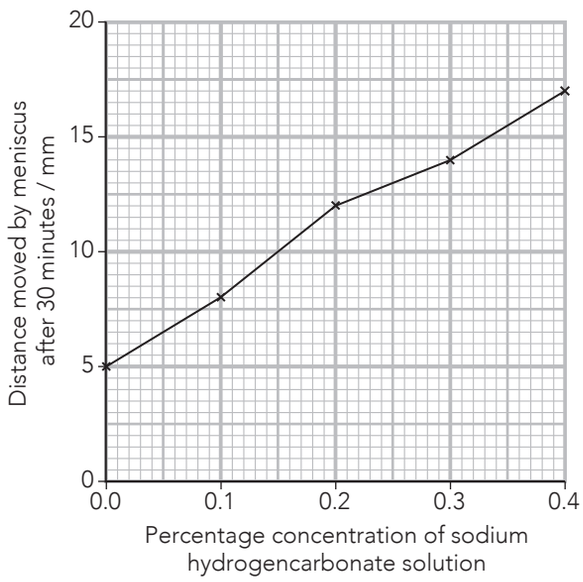
b Any two from:

- to ensure that they were all exposed to the same light intensity ;
- to standardise a variable ;
- and so that light was not a limiting factor ;

[Max. 2]

Chapter 6 continued

c



axes the right way round **[1]** ; both axes fully labelled with units **[1]** ; good scales on both axes **[1]** ; points plotted accurately **[1]** ; lines drawn precisely between points **[1]** ;

d Any two from:

- it is a limiting factor at all concentrations used ;
- as sodium hydrogencarbonate concentration increases, distance moved by meniscus increases ;
- therefore, as carbon dioxide concentration increases, rate of photosynthesis increases ; **[Max. 2]**

e i Accept any **two** sensible suggestions, for example:

- leakage of air into or out of the syringes ;
- variation in the plants (size, activity) ;
- difficulty in reading the position of the meniscus precisely against the scale on the ruler ;
- (do not accept anything that sounds like a mistake made by the learners, such as not ensuring their eye is parallel with the meniscus) ;

[Max. 2]

ii Accept any **two** sensible suggestions relating to the answers in **i**, for example:

- use petroleum jelly to make the syringe plungers airtight ;
- use plant pieces of identical mass ;
- use a glass tube with a scale on it ;

[Max. 2]

Chapter 7

Getting started

1 Starch is a carbohydrate.

2 It is made of many glucose molecules linked together.

3 Protein molecules are made of amino acids linked together.

4 Lipase digest fats to fatty acids and glycerol.

5 It is an enzyme. All enzymes are protein molecules.

Science in context: Stomach acid

1 Carnivores such as lions and hyenas may eat meat that is not fresh, and is therefore likely to contain large numbers of potentially harmful bacteria. The acid in their stomachs helps to kill these, preventing infection. It is also possible that the acid helps with the digestion of proteins from the meat in the stomach, where the enzyme pepsin requires acidic conditions to work.

2 When there is no food in the stomach, there is no need for acid to be produced, so this would be wasteful. Also, the acid can damage the stomach wall.

Questions

1 Fats and oils are needed to make cell membranes. They also form an insulating layer beneath the skin, and a protective layer around some body organs.

2 Starch is a carbohydrate that can be eaten and avoid these risks.

3 For example:

Nutrient	Main dietary sources	Uses in the body
Carbohydrate	Grains and foods made from them – e.g. rice, pasta, bread; potatoes; sweet foods	For energy, which is released in respiration.
Fat and oil	Cooking oil, meat, eggs, dairy products, oily fish	For energy, released in respiration. To make cell membranes.
Protein	Meat, fish, eggs, dairy products, pulses (peas, beans, lentils), nuts and seeds	Making new cells, and therefore for growth. Making haemoglobin and antibodies.

4 The alimentary canal is part of the digestive system. It is the tube that food moves through. There are also other organs in the digestive system.

5 liver, pancreas, gall bladder, salivary gland

6 mouth, oesophagus, stomach, duodenum, ileum, colon, rectum, anus

7 a mouth

b mouth, stomach, duodenum

c ileum, colon

d anus

8 a The molars and premolars increase the surface area of food, by grinding it.

b It increases the surface area of the food, making it easier for enzymes to act on it.

9 It has a broad, ridged surface that crushes food as it grinds against the tooth on the other jaw. It has a very strong layer of enamel covering its surface, which is not easily damaged by grinding food. It is attached to the jawbone with fibres, so it can move a little rather than snap off.

10 mouth and duodenum

11 stomach and duodenum

12 a mouth and duodenum

b on the surface of the epithelium lining the small intestine

13 a pancreas

b duodenum

Chapter 7 continued

14 **a** from the stomach wall

b Pepsin has an optimum pH of 2. As the stomach contents move into the duodenum, bile is added. This is alkaline, and it raises the pH to just above 7. Pepsin is denatured and stops working.

15 Bile breaks up large drops of fat into tiny droplets which disperse through the water contents of the duodenum. This increases the surface area of fat that lipase can contact, and so lipase can break the fats into fatty acids and glycerol more quickly.

Exam-style questions

1 B ; **[1]**

2 B ; **[1]**

3 C ; **[1]**

4 C ; **[1]**

5 D ; **[1]**

6 **a** G: large intestine / colon **[1]** ; J: liver **[1]** ;

b A and D ; **[2]**

c E ; **[1]**

d Any six from:

- secretes protease ;
- which digests protein ;
- to amino acids ;
- reference to chemical digestion ;
- secretes hydrochloric acid ;
- which provides a suitable pH for enzymes ;
- kills microorganisms ;
- churns food ;
- reference to physical digestion ;

[Max. 6]

7 **a** A: incisor **[1]** ; B: canine **[1]** ; C: molar **[1]** ;

b tooth A: ingestion **[1]** ; bites off pieces of food **[1]** ; tooth C: physical digestion **[1]** ; crushes food / increases its surface area **[1]** ;

c drawing shows all parts of tooth; correct labels to enamel; dentine; pulp; nerves / blood vessels; cement ; **[6]**

8 **a** Any two sources, for example: rice, bread, potatoes, pasta, maize, any sweet foods ; **[1]**

b for energy **[1]** ; released by respiration **[1]** ;

c amylase **[1]** ; breaks down starch to maltose **[1]** ; in the mouth and duodenum **[1]** ; maltase **[1]** ; breaks down maltose to glucose **[1]** ; on the surface of the epithelial cells in the duodenum **[1]** ;

9 **a** small intestine / duodenum / ileum ; **[1]**

b Any four from:

- epithelial cell ;
- secretes maltase ;
- which digests maltose to glucose ;
- has microvilli to increase surface area ;
- ref. to absorption ; **[Max. 4]**

c lubrication ; **[1]**

d Any two from: amino acids ; glucose ; vitamins ; mineral ions ; water ; **[Max. 2]**

e lacteals ; **[1]**

Chapter 8

Getting started

Possible sentence completions could be:

Plants take up water **by osmosis / through their root hairs / from the soil**.

Water gets to the leaves of plants **through xylem / from the roots**.

The sentences suggested by groups can then be combined to make two sentences summarising what learners should already know about this topic.

Science in context: The world's tallest trees

1 Learners may suggest osmosis. They will later find that this is also how water reaches individual cells in plants that do have xylem, and how it first enters the plant and moves across the root into the xylem vessels.

2 The purpose of this question is to help learners to appreciate that supplying the leaves of a tree with water purely by osmosis is not a possibility. They can estimate the time it would take by multiplying 116 m × 10 (to convert to cm) and then by 10 minutes. This gives a time of 11 600 minutes, which is 193 hours or just over 8 days.

Questions

1 support; transport of water and mineral ions

2 lignin

3 transport of sugars and amino acids

4 In roots, xylem and phloem are in the centre. The xylem forms a 'cross' or 'starfish' shape, with phloem between the 'arms'; In stems, xylem and phloem are arranged close to the edge. They form roughly triangular areas. In each one, the phloem is closer to the outer edge of the stem, with the xylem closer to the centre; In leaves, xylem and phloem are found in the vascular bundles (veins). The xylem is closer to the upper surface of the leaf, and the phloem is below the xylem.

5 Any two from:

- Lignified walls make the xylem strong enough to support the plant or a leaf;
- Lignified walls make sure that the vessels stay open and do not collapse inwards;
- Dead cells with no contents and no end walls provide a continuous tube through which a column of water can flow;
- Diameter of the vessels is narrow enough to support the water column, but wide enough to allow plenty of water to flow through easily;

6 to absorb water and mineral ions

7 It is long and thin, and therefore has a relatively large surface area. This increases the rate at which it can absorb water and mineral ions.

8 The solution in the soil has a relatively low concentration of solutes compared with the solution inside the root hair cell. These solutions are separated from each other by the partially permeable cell membrane. Water moves into the cell through this membrane by osmosis, from a dilute solution to a more concentrated solution.

9 Water moves from a high water potential in the soil into the lower water potential inside the root hair cell, down a water potential gradient. It continues to move from cell to cell towards the centre of the root, by osmosis, down the water potential gradient.

Chapter 8 continued

Experimental skills 8.1

1 xylem

2 the vascular bundles (veins)

3 Temperature is the variable to be changed. A suitable range would be between 0 °C and perhaps 80 °C, with intervals of 10 °C or 20 °C. This could be done using water baths.
The most important variables to be kept constant include the size of the celery stalk and the concentration of the dye.
If the dye can be seen in the stalk without having to cut it, learners could measure the distance travelled by the dye in a set time period – for example, every two minutes. If it cannot be seen, they will need to have several stalks at each temperature, and cut one of them across at a set distance (e.g. 10 cm) after a set time – say every two minutes – to determine how long it takes the dye to travel this distance.
The main safety risk is the sharp blade used to cut the stalks. Learners should describe how they will avoid cutting themselves or someone else with the blade.

Questions

10 root hair cells, root cortex cells, xylem, mesophyll cells

11 **a** liquid

b liquid

c gas

12 Water evaporates from the surfaces of the mesophyll cells, so the larger the surface area the more water can evaporate. The loss of this water from the cells reduces the water potential of their contents, causing water to move from the xylem vessels by osmosis, down a water potential gradient. This loss of water at the top of the xylem vessels reduces the pressure, so that the pressure difference between the water at the bottom and top of the xylem makes water flow upwards through them.

13 The water molecules are attracted to one another, so they stick together. This keeps the water in an unbroken column.

Experimental skills 8.2

1 **a and b** Answers will depend on the learner's experience as they used the potometer.

2 Water moves into the cut end of the shoot because water evaporates from the leaves. This causes a transpiration pull, so that water moves up the xylem vessels in the stem.

3 The line graphs should:

- have time / minutes on the *x*-axis, with a suitable scale that uses at least half of the graph paper provided
- have distance moved by meniscus / mm (or cm) on the *y*-axis, with a suitable scale that uses at least half of the graph paper provided
- have points plotted as neat crosses or encircled dots
- have lines drawn from point to point with a ruler or best fit lines
- have lines clearly labelled, either directly on the graph or using a key.

Questions

14 Transpiration happens faster when temperature is higher and wind speed is greater.

15 time

16 On a hot day, water molecules have more kinetic energy, so water evaporates faster from the surface of the mesophyll cells and diffuses faster through the stomata. The plant therefore loses water faster. If it cannot increase the rate at which it absorbs water from the soil to the same extent, then water loss will cause it to wilt.

17 The leaves are folded, exposing less of their surface to the air. This will reduce the rate at which water vapour is lost from them, which helps the plant to conserve water.

18 Leaves are a source, and the trunk and roots are sinks.

19 Trunk and roots are sources, and the growing buds and leaves are sinks.

Chapter 8 continued

20 Transpiration happens at the top of the xylem vessels, so this is where the pressure is reduced in the xylem vessels. The pressure is always lower at the top than the bottom, so the water will always flow upwards.

Exam-style questions

1 B ; [1]

2 C ; [1]

3 C ; [1]

4 C ; [1]

5 B ; [1]

6 a xylem ; [1]

b Any two from:

- water was lost from the leaves ;
- by transpiration ;
- pulling water up the capillary tube ;

[Max. 2]

c total distance moved in 10 minutes is 34 – 10 = 24 mm; so mean distance per minute 24 ÷ 10 = 2.4 mm per minute ; [2]

d temperature; higher ;
or
humidity; lower ; [2]

7 a X = cortex [1] ; Y = phloem [1] ; Z = xylem [1] ;

b into root hairs [1] ; by osmosis [1] ;

c through root cortex cells [1] ; then through xylem [1] ; then to mesophyll cells [1] ;

8 a number of stomata in 0.06 mm^2 is 20 (allow 18, 19 or 21) [1] ; so, number in 1 mm^2 is 333 (to nearest whole number) [1] ;

b i root hairs absorb water from the soil [1] ; a large surface area increases the rate at which this happens [1] ;

ii this means that the mesophyll cells have a large surface area [1] ; from which water evaporates [1] ; filling the air spaces with water vapour that can diffuse out through stomata [1] ;

iii water can flow up xylem as a continuous column [1] ; pulled up by, transpiration pull / difference in pressure at top and bottom [1] ;

c phloem transports sucrose and amino acids but xylem does not [1] ; phloem transports in both directions but xylem transports only upwards [1] ;

9 a for photosynthesis / to make glucose / to make carbohydrates [1] ; carbon dioxide reacts with water [1] ;

b it evaporated from the surfaces of mesophyll cells [1] ; into the air spaces [1] ;

c i Any five from:

- percentage hydration decreases (over time) ;
- from 100% at day 1 to 30% at day 5 ;
- fluctuates each day ;
- drops during the day and increases at night ;
- drops faster than it increases ;
- drops by a greater amount than it increases ;

[Max. 5]

ii Any four from:

- percentage hydration of the soil drops ;
- (so) less water can be taken in by osmosis through root hairs ;
- water lost by transpiration cannot be (completely) replaced ;
- during daylight, it is hotter / stomata are open, so water loss exceeds water uptake ;
- at night, it is cooler / stomata are closed, so water uptake exceeds water loss ;

[Max. 4]

iii it has wilted [1] ; leaves have collapsed / other suitable description [1] ; leaf cells have lost their turgidity [1] ;

Chapter 9

Getting started

Learners may show:

oxygen / glucose / water / other nutrients entering the cell

carbon dioxide / urea leaving the cell

They may know that these substances are brought to and from the cell in the blood. They may also give other detail, such as that oxygen enters the blood in the lungs, or that nutrients enter the blood in the small intestine.

Science in context: Blood transfusions

There are no 'correct' answers for these questions.

1 Learners are likely to differ in their opinions; encourage them to listen to the opposite point of view and consider arguments on both sides. For example, some learners may think that paying donors is only fair and could increase the quantity of blood that is donated, while others may think that giving blood should be something that is done freely.

2 Learners may appreciate that artificial blood supplies could be greater and more reliable than donated blood and could be useful in emergency situations where it is not possible to test the recipient for their blood group.

Questions

1 The left side contains oxygenated blood, and the right side contains deoxygenated blood.

2 as it passes through the body organs other than the lungs; oxygen diffuses out of the blood into the body cells, where it is used in aerobic respiration

3 The blood goes back to the heart after it has been oxygenated and is then pumped out again. Oxygenated blood therefore arrives at the body organs at higher pressure, meaning that it is travelling more quickly through the arteries. In a single circulatory system, the blood does not go back to the heart after being oxygenated, so is travelling at a lower pressure as it moves towards the body organs.

4 left atrium, left ventricle, right atrium, right ventricle

5 left atrium and left ventricle

6 away from

7 towards

8 The muscles in the walls of the ventricles contract. This squeezes inwards, making the volume inside the heart smaller, which increases the pressure and pushes the blood out.

9 The septum. If the two types of blood were allowed to mix, the blood flowing to the organs would not contain as much oxygen as if it is purely oxygenated blood.

10 The atrioventricular valves are the ones between the atria and ventricles. The semilunar valves are in the entrances to the aorta and pulmonary artery.

11 The atria only need a small quantity of muscle, because the contraction of this muscle needs only to produce enough force to push the blood into the ventricles. The ventricles must produce enough force to push the blood out of the heart and to body organs.

12 In the heart wall. They provide oxygen and nutrients for the heart muscle.

13 Cholesterol can form deposits in their walls.

14 Using an ECG, measuring pulse rate or listening to the sounds of the valves closing.

15 a 0.7 s

b 60 ÷ 0.7 = 86 beats per minute

16 The septum separates oxygenated blood from deoxygenated blood, ensuring that all of the blood that enters the aorta is fully oxygenated. The bicuspid valve is in the entrance to the aorta, and it prevents blood flowing back into the ventricles after it has been forced into the aorta as the muscles in the ventricle wall contract. This ensures that it flows forwards in the aorta at high pressure.

Chapter 9 continued

Experimental skills 9.1

1 The line graph will depend on the learner's results.

2 Answers will depend on the learner's results. They are likely to find that heart rate fluctuated a little before exercise, then increased rapidly, and decreased slowly after exercise ended.

3 Muscle contraction needs energy, which is obtained from aerobic respiration. As muscles work harder, they need more energy and therefore aerobic respiration happens faster. They therefore need more oxygen, which is supplied to them by the blood. A faster heart rate moves blood faster, supplying oxygen more quickly.

Questions

17 a artery

b capillary

c vein

18 a in the lungs

b in the body organs

c pulmonary artery

19 The blood pulses as it is forced through the arteries – it is at high and fluctuating pressure. The elastic tissue in artery walls allows them to expand as a high-pressure pulse of blood flows through, rather than bursting. They can then recoil to their normal diameter in between pulses. This helps to even out the blood pressure. Veins, on the other hand, carry blood that has already been through capillaries and has lost most of its pressure, and is not pulsing.

20 Unlike all other organs, the liver has two separate blood supplies. The hepatic artery brings oxygenated blood, and the hepatic portal vein brings blood rich in nutrients, from the small intestine.

21 A white blood cell has a nucleus.

22 Blood plasma is the liquid part of blood.

23 preventing blood loss and preventing the entry of pathogens

24 A phagocyte normally has a lobed nucleus, whereas a lymphocyte has a large, round nucleus that almost fills the cell.

25 Blood plasma contains the soluble protein fibrinogen, which forms insoluble fibres of fibrin. Platelets release a substance that makes this happen. Platelets also clump together to form part of the clot.

Exam-style questions

1 D ; **[1]**

2 A ; **[1]**

3 C ; **[1]**

4 A ; **[1]**

5 D ; **[1]**

6 a Any two from:

- it is larger ;
- it has a nucleus ;
- it has a less regular shape ;
- it does not contain haemoglobin ;

[Max. 2]

b diameter of cell in diagram is 20 mm = 20 000 µm ;
(magnification = image size ÷ actual size)
actual size is 7 µm
magnification = 20 000 ÷ 7 = ×2860 ; **[2]**

c Any three from:

- (take up oxygen) when oxygen concentration is high ;
- at the alveoli / in the lungs; oxygen combines with haemoglobin / forms oxyhaemoglobin ;
- carried in blood (from lungs) to rest of body ;
- releases oxygen when oxygen concentration is low ; **[Max. 3]**

d producing antibodies **[1]** ;
phagocytosis **[1]** ;

Chapter 9 continued

7 a Any two from:
- measuring pulse rate ;
- ECG ;
- listening to valves closing ; **[Max. 2]**

b (activity of heart) increases when exercising **[1]** ; beats faster and harder **[1]** ; decreases gradually when exercise finishes **[1]** ;

c Any six from:
- blood cannot supply oxygen to heart muscle ;
- muscle cannot respire aerobically ;
- cannot release energy for contraction ;
- heart stops beating; take regular exercise ;
- do not smoke ;
- eat a balanced diet / reduce (saturated) fat intake ;
- reduce stress ; **[Max. 6]**

8 a A: just starting to contract **[1]** ; B: just starting to relax **[1]** ;

b (time between A and next corresponding position on the graph is) 0.75 s **[1]** ;

c 60 ÷ 0.75 **[1]** ; (allow error carried forward from b) = 80 beats per minute **[1]** ;

d prevent blood flowing back from ventricles into the atria **[1]** ; blood pumped into, arteries / aorta **[1]** ;

e line rises and falls at exactly the same times and in the same pattern as for the left ventricle line **[1]** ; volume (height of the line on the graph) is lower than previous line **[1]** ;

9 a i A: nucleus **[1]** ; B: mitochondrion **[1]** ;

ii Any two from:
- to allow substances to move quickly ;
- between the capillary and surrounding cells ;
- by diffusion ;
- any two examples of substances: oxygen / carbon dioxide / named nutrients ; **[Max. 2]**

iii red blood cell is transporting oxygen **[1]** ; reduces distance for oxygen to diffuse, out of the capillary / to surrounding cells **[1]** ;

b Any three from:
- suitable description of shape difference ;
- rbc has no, nucleus / structure A ;
- rbc has no, mitochondria / structure B ;
- rbc contains haemoglobin ; **[Max. 3]**

c plasma ; **[1]**

Chapter 10

Getting started

There is a very wide variety of sentences that learners could write. For example:

Bacteria and viruses are pathogens, which are destroyed inside our body by antibodies produced by white blood cells.

Science in context: Global outbreaks of measles

1 Learners may be aware that some parents think that vaccinations are harmful to health. There is a lot of misinformation on the internet, and it is worth listening to what learners themselves have picked up about the effects of vaccines. In some countries, this has become a political or religious issue, so it is important to take care when chairing this discussion.

2 There is no correct answer to this question. Opinions may be divided between those who think that it is a parent's right to decide whether or not to have their child vaccinated, and those who think that the health of the school community should take precedence over that of an individual. These are not easy decisions to make, and learners should be encouraged to look at both points of view.

Questions

1 A disease that can be passed from one person (or other organism) to another. Transmissible diseases are caused by pathogens.

2 Unbroken skin is a physical barrier that stops most pathogens moving through to the underlying tissues. If skin is broken, a blood clot seals the wound and prevents pathogen entry.

3 The acid kills bacteria in food, preventing the entry of pathogens that might cause food poisoning or other infections.

4 Water that is not clean contains microorganisms, and some of these are pathogens. If you drink water containing pathogens or use it in ways that allow the pathogens to get from the water into your mouth, it can cause serious illness.

5 The water in a well comes from deep underground, where it is less likely to have been contaminated with urine or faeces. It is therefore less likely to contain pathogens from the body of an infected person.

6 a Covering food keeps animals such as houseflies away from it. Houseflies transfer pathogens on their feet or in their saliva. If the food is in a warm place, these pathogens can breed quickly, so that by the time someone eats the food there are large numbers of pathogens, which could cause food poisoning or other illnesses.

b Keeping the food cold reduces the rate at which bacteria can breed. Even if there are harmful bacteria on the food, when their numbers remain small there is less chance of getting ill if you eat them.

7 The cholera bacterium is transmitted in water. At home, people generally have a source of clean water that they can rely on. When displaced, people may not have a clean water supply. If many people are living in close proximity in unhygienic conditions, there is a strong possibility that pathogens in their faeces can get into water that others will use for drinking, food preparation or washing.

8 Glucose, sodium ions and chloride ions in the drinks can be absorbed from the small intestine into the blood. The extra glucose in the blood reduces its water potential, which reduces the water potential gradient from the blood into the lumen of the intestine. Less water therefore moves from the blood into the lumen of the intestine, and therefore there is less diarrhoea. The chloride ions in the drink help to replace the chloride ions lost from the blood. So, the drinks help to reverse the loss of water and chloride ions that is the main cause of fatalities resulting from cholera infection.

9 An antigen is a molecule on a cell that is not normally found in the body – such as a pathogen – and that the body recognises as 'foreign'. An antibody is a protein that is secreted by lymphocytes, which can bind to its complementary antigen.

Chapter 10 continued

10 The antigen and antibody have complementary shapes, so that they fit together precisely.

11 **a** It takes time for the lymphocytes that can make the appropriate antibody for this pathogen to make contact with the antigen on the pathogen, then to divide and produce a clone of identical cells, which can then make large quantities of the antibody.

b The number rises rapidly between day 0 and day 1, and then decreases more slowly, reaching 0 at the end of day 3. The number of bacteria is able to increase rapidly at first, because there are no antibodies to stop them dividing. But as the quantity of antibodies increases, the bacteria are immobilised or killed, and the rate at which they die becomes greater than the rate at which they reproduce. Their numbers therefore fall.

12 The body now contains memory cells, which are able to react immediately to the presence of the bacteria and very rapidly produce large quantities of the specific antibody that binds with the antigen on these bacteria. The number of bacteria therefore has time to increase only very slightly, and their numbers are reduced to 0 by the end of day 1.

13 The response would look like the first graph because the antigens on this new bacterium would be different. The memory cells produced from the first infection give no protection against any other type of pathogen.

14 Through having a transmissible disease and recovering from it; by being given a vaccination containing weakened pathogens.

15 By being given an injection of ready-made antibodies; through breast milk.

16 Active immunity lasts much longer than passive immunity. In active immunity, memory cells are made, but this does not happen with passive immunity.

17 The pathogen is unable to breed in a person who has been vaccinated. If enough people have been vaccinated, this greatly reduces the number of people who can be a host for the pathogen, making it much less easy for the pathogen to spread through the population.

Exam-style questions

1 C ; **[1]**

2 B ; **[1]**

3 D ; **[1]**

4 A ; **[1]**

5 A ; **[1]**

6 **a** All transmissible diseases are caused by pathogens, which are passed from one host to another. The lining of the respiratory passages helps to prevent this from happening by producing mucus. ; **[3]**

b **i** idea that skin is a barrier to entry of pathogens through it **[1]** ; blood clots to seal wounds **[1]** ;

ii hydrochloric acid **[1]** ; is secreted by the stomach **[1]** ; killing microorganisms in food **[1]** ;

7 **a** Any five from:

- introduction of, dead / weakened, pathogens ;
- recognised by (specific) lymphocytes ;
- antibodies produced ;
- antibodies are specific to, pathogen / antigen ;
- memory cells produced ;
- which respond quickly on second entry of same pathogen ; **[Max. 5]**

Chapter 10 continued

b i Any three from:

- increased ;
- from 15 000 to 76 000 (allow some leeway with figures) ;
- fluctuated ;
- maximum number of cases was 760 000 in, 1957 / 1958 ; **[Max. 3]**

ii rapid decrease in number of cases **[1]** ; to 0 by 1991 **[1]** ; many children now immune to measles **[1]** ; ref. to herd immunity / few hosts for measles virus **[1]** ;

8 a active, passive, passive, active ;
(any two correct for one mark) **[2]**

b antibodies give immediate protection **[1]** ; weakened pathogens stimulate the production of her own antibodies **[1]** ; but it takes time for her lymphocytes to, recognise the pathogen / make antibodies **[1]** ;

c Any four from:

- pathogen has antigens ;
- antibodies have complementary shape to antigen ;
- antibodies bind with antigens ;
- (may) destroy the pathogen directly ;
- (may) clump the pathogens / mark them, for destruction by phagocytes ;
[Max. 4]

9 a genetic material / DNA / RNA ; **[1]**

b Any five from:

- proteins in virus coat are antigens ;
- lymphocytes make antibodies ;
- which have complementary shape to antigens ;
- produce memory cells ;
- which can produce antibodies quickly on next exposure to antigen ;
- these antibodies cannot bind with other antigens ;
- so cannot protect against new strains of the virus ; **[Max. 5]**

Chapter 11

Science in context: Sleep apnoea

1 There is no 'right' answer for this – it is intended as an intriguing issue to encourage learners to think separately about their breathing rate and heart rate. One possible answer is that we use breathing for purposes other than 'staying alive' – such as talking. We have therefore evolved to have some control over this process, whereas there is no advantage in being able to consciously control heart rate.

2 A person with sleep apnoea is likely to get insufficient sleep each night. This can reduce their alertness and increase their reaction time, increasing the chance of an accident.

Questions

1 The reactants in aerobic respiration are the products of photosynthesis. The reactants in photosynthesis are the products of aerobic respiration.

2 every cell

3 During photosynthesis, chlorophyll captured energy from sunlight and transferred it to glucose molecules.

Experimental skills 11.1

1 Answers will depend on the learner's results.

2 Answers will depend on the learner's results. The expected results would be that the mean number of bubbles increases as temperature increases, and then falls after a certain temperature has been reached. The answer should include reference to this temperature. Note: Even if the results are not as expected, learners should be given full credit for a clear description of the results that they obtained.

3 If the results were as expected, learners should explain:

- that the mean number of bubbles indicates the rate of respiration
- that the rate of respiration increases as temperature increases because enzyme and substrate molecules have more kinetic energy at higher temperatures, and therefore collide more frequently
- but as temperature increases further, the enzyme molecules are denatured (lose their shape) so that the active site is not a complementary shape for the substrate molecules, and enzyme–substrate complexes cannot be formed.

4 Answers will depend on the learner's prediction, and their actual results.

5 Yeast produces carbon dioxide in both aerobic respiration and anaerobic respiration.

6 All the glucose is used up.

Questions

4 mouth or nose; trachea; bronchi; bronchioles; alveoli; wall of alveolus; wall of capillary;

5 The arrow for oxygen goes into a red blood cell, because oxygen is transported in combination with haemoglobin in red blood cells. The arrow for carbon dioxide comes from the blood plasma, because most carbon dioxide is transported in solution in the plasma.

6 The arrows in the bronchiole represent mass flow. The arrows showing carbon dioxide and oxygen moving into and out of the blood represent diffusion.

7 Emphysema results in a reduction of the surface area of the alveoli, and so less oxygen is able to diffuse into the blood in a given time. This reduces the oxygen supply to cells, which therefore cannot undergo aerobic respiration as rapidly, and cannot release as much energy, as normal. The person may therefore find it difficult to exercise.

Chapter 11 continued

Experimental skills 11.2

1 When you breathe out, air moves into the short tube in A and the long tube in B. Expired air therefore only bubbles through the limewater in B.
When you breathe in, air is drawn from the end of the short tube in A, causing air to be pulled into the limewater in A through the long tube.

2 Learners should find that the limewater goes cloudy more quickly in tube B. This shows that there is more carbon dioxide in expired air than in inspired air.

Questions

8 The inner surface of the alveoli is moist. Water from this surface evaporates and is breathed out with the expired air.

9 The percentage is 78%. As nitrogen gas is not used in the body, the nitrogen concentration in the blood remains the same as in the air in the lungs, because nitrogen molecules diffuse between the air and blood until equilibrium is reached.

10

Muscle	Breathing in	Breathing out
diaphragm	contracts	relaxes
external intercostal	contracts	relaxes
internal intercostal	relaxes	contracts

Experimental skills 11.3

1 Look for:
- axes the right way round, and fully labelled with units
- suitable scales on both axes – they should go up in regular intervals and use at least half of the grid provided
- points correctly plotted as small, neat crosses
- clean, clear, ruled lines that join precisely at the centres of the crosses.

2 Answers will depend on the learner's results.

Exam-style questions

1 C ; **[1]**

2 C ; **[1]**

3 B ; **[1]**

4 B ; **[1]**

5 C ; **[1]**

6 a glucose + oxygen **[1]**; → carbon dioxide + water **[1]** ;

b Any three from:
- muscle contraction ;
- cell division ;
- active transport ;
- growth ;
- passage of nerve impulses ;
- maintenance of a constant body temperature ; **[Max. 3]**

c ethanol **[1]** ; carbon dioxide **[1]** ;

7 a i 12 ; **[1]**

ii 0.5 dm^3 ; **[1]**

b i 21 ; **[1]**

ii 1.1 dm^3 ; **[1]**

c Any four from:
- brain senses the pH of blood ;
- pH decreases during exercise ;
- because more, carbon dioxide / lactic acid, is dissolved in the blood plasma ;
- brain responds by sending more frequent impulses to the breathing muscles ;
- so, they contract harder and more frequently ; **[Max. 4]**

Chapter 11 continued

d Any five from:

- muscles need more energy for contraction ;
- deeper / more rapid, breathing brings more fresh air into the lungs ;
- more oxygen can diffuse into the blood more quickly ;
- more oxygen is supplied to the muscles ;
- so aerobic respiration can happen faster ;
- releasing more energy from glucose ; **[Max. 5]**

8 a

	Breathing in	Breathing out
External intercostal muscles	contract	relax
Internal intercostal muscles	relax	contract
Muscles in diaphragm	contract	relax
Volume change in thorax	increases	decreases
Pressure change in thorax	decreases	increases

one mark per correct row ; **[5]**

b i 5 minutes ; **[1]**

ii reference to oxygen debt **[1]** ; anaerobic respiration in muscles **[1]** ; produced lactic acid **[1]** ; (lactic acid) broken down in liver **[1]** ; by, aerobic respiration / combining with oxygen **[1]** ;

9 a i D ; **[1]**

ii C ; **[1]**

iii Any two from:

- all structures that are visible are found in both animal and plant cells ;
- cannot see the edge of the cell so do not know if it has a cell wall ;
- no chloroplasts visible but this does not mean it is not a plant cell ;
- no large vacuole visible but this does not mean it is not a plant cell ; **[Max. 2]**

b aerobic respiration **[1]** ; glucose combined with oxygen **[1]** ; to produce carbon dioxide and water **[1]** ; and release energy **[1]** ;

c i to provide energy for contraction ; **[1]**

ii to provide energy for protein synthesis ; **[1]**

d function of red blood cells is to transport oxygen **[1]** ; having no mitochondria means they will not use up oxygen in aerobic respiration **[1]** ;

Chapter 12

Getting started

Eyes: light. Ears: sound. Skin: temperature, pressure. Tongue: chemicals (taste). Nose: chemicals (smell).

Science in context: Reaction times

1 Reaction times in sprint races have been measured in thousands of races over the years. The evidence is that no one has ever responded in less than 0.1 s, and most reaction times are well above this value.

(If learners research this issue, they will find that measured reaction times have steadily reduced since 2004, but this is thought to be a reflection of changes in the sensors and measuring technology, rather than in the athletes themselves.)

2 The width of the track is $9 \times 1.22 = 10.98$ m. The time for the sound to travel 10.98 m is $10.98 \div 330 = 0.03$ s.
So, if a runner in the inside lane and a runner in the outside lane have the same reaction time, the one in the outside lane would leave his or her blocks 0.03 s after the one in the inside lane. Looking at the times for the gold, silver and bronze medals in the men's 100 m race in Rio, the difference between silver and gold is only 0.02 s. So this could make a real difference to the outcome of the race.

Questions

1 They have a cell membrane, nucleus, cytoplasm, mitochondria and ribosomes.

2 They have a very long axon, along which impulses can travel long distances quickly.

3 It coordinates electrical impulses in the nervous system; it receives impulses from different receptors and sends impulses to appropriate effectors.

4 a in a small swelling just outside the spinal cord

b in the spinal cord

c in the spinal cord

5 Sensory neurones have long cytoplasmic extensions on either side of the cell body, whereas motor neurones have only one long extension and relay neurones have none.

6 There is a very wide variety of possible answers. Look for genuine reflex actions that happen automatically, not reactions that are decided on.

7 The great advantage of reflex actions is that they happen much more quickly than actions where we take a decision. This can help us to avoid danger – for example, by closing the eyes when we see something moving quickly towards them; dropping something that is burning the hand. The disadvantage of reflex actions is that they are automated – the same stimulus always brings about the same response. If all our actions were like that, we would behave like pre-programmed robots, with no decision-making or the wide range of actions that humans perform.

Activity 12.1

1 Divide the time by the number of people, to find the mean reaction time.

2 People generally respond faster as the experiment is repeated. This is because learning is taking place.

3 Usually, the squeeze travels more slowly when it is sent in the opposite direction. This is because the people in the circle have to 'unlearn' what they have just learnt and start again.

4 Answers will depend on the sites that the learners find. There is no 'correct' answer to which method is best. We have no way of knowing whether the time given on the website is correct or not. However, it is likely to be very reliable.

Chapter 12 continued

Questions

8 Information moves along a neurone as an electrical impulse. (Learners cannot be expected to know any more about how this happens; it is not an electrical current but does involve the movement of charged ions.) This electrical impulse cannot cross the synaptic gap. Instead, the neurotransmitter molecules – i.e. chemicals – diffuse across the gap. This stimulates an electrical impulse to start in the second neurone.

9 The shapes of the two molecules are 'mirror images' of one another. This allows the neurotransmitter molecules to fit into the receptor molecules like pieces in a jigsaw puzzle.

Activity 12.2

The dot should disappear, as its image falls onto the blind spot in the right eye.

Questions

10 Eyes: light. Ears: sound. Skin: temperature, pressure. Tongue: chemicals (taste). Nose; chemicals (smell).

11 **a** The cornea refracts light as it enters the eye.

b The iris controls the diameter of the pupil, and therefore controls the amount of light that enters the eye.

c The lens makes fine adjustments to the refraction of light rays, bringing them to a focus on the retina.

d The retina contains receptor cells that respond to the stimulus of light by generating electrical impulses in neurones.

e The optic nerve transmits these electrical impulses to the brain.

12 This is a part of the retina away from the fovea. There are far more rod cells than cones – the fovea is densely packed with cones.

13

Focusing	Ciliary muscle	Suspensory ligaments	Lens
on a distant object	relaxes	tense	pulled thin
on a near object	contracts	loose	fat

14 pancreas: insulin; adrenal glands: adrenaline; testes: testosterone; ovaries: oestrogen

15 They travel in the blood plasma, usually in solution.

16 Any situation in which a person is frightened or angry – i.e. any fight or flight situation. Adrenaline is also secreted when we are nervous, such as before an interview or examination.

17 It increases breathing rate and heart rate, which provides more oxygen to muscle cells so they can release more energy for contraction, by aerobic respiration. It makes the pupil wider, to allow more light into the eyes for better vision of the perceived danger.

Experimental skills 12.1

1 The shoots of the seedlings will grow towards the light, showing positive phototropism.

2 Dish B was a control, so that we could compare the response of the seedlings with light from one side with those with light from all around.

3 These seedlings are likely to grow very tall and thin, and may be yellow or white rather than green. (This is called etiolation. The seedlings do not make chlorophyll because there is no light for them to absorb. They grow tall quickly, as this could increase the chance of reaching light.)

Chapter 12 continued

Experimental skills 12.2

1 negative gravitropism

2 The control is the plant standing upright.

3 This is to standardise a variable, ensuring that light does not affect the results.

Experimental skills 12.3

1 Learners should find that all of the roots grow downwards, towards the direction from which gravity is acting.

2 positive gravitropism

3 Roots needs to grow down into the soil, to anchor the young seedling and to absorb water and mineral ions.

Experimental skills 12.4

1 The roots will probably continue to grow in the direction in which they started off.

2 In most plants, roots do not respond to unidirectional light. The results are likely to show no difference between the growth on the two pieces of apparatus. The roots will not grow either towards or away from the light on the static turntable.

Questions

18 Shoots grow towards light, so they show positive phototropism. Shoots grow away from gravity, so they show negative gravitropism.

19 Roots grow towards gravity, so they show positive gravitropism. They do not respond to light, so do not show phototropism.

20 The diagram should show:

- a shoot lying horizontally
- auxin being made in the cells at the tip of horizontal shoot
- auxin diffusing back into the shoot from the tip
- auxin accumulating on the lower surface of the shoot
- the cells on the lower surface elongating faster than the ones on the upper surface
- and therefore, the shoot bending upwards as it grows.

Exam-style questions

1 C ; [1]

2 A ; [1]

3 A ; [1]

4 D ; [1]

5 A ; [1]

6 a i chemical substance made by a gland **[1]** ; carried in the blood **[1]** ; modified activity of target organs **[1]** ;

ii adrenal (glands) ; [1]

iii pancreas ; [1]

b i the diameter of the pupil increases ; [1]

ii reduction in light intensity ; [1]

c the action is slower **[1]** ; the effect lasts longer **[1]** ;

7 a eye ; [1]

b in the retina ; [1]

c as electrical impulses **[1]** ; along the optic nerve **[1]** ;

d i growing; towards the light ; [2]

ii increase the amount of light that falls onto its leaves **[1]** ; so, it can photosynthesise more **[1]** ;

e positive; gravitropism ; [2]

8 a contract **[1]** ; decreases **[1]** ; fat **[1]** ; more **[1]**;

b wide pupils allow more light to enter the eye **[1]** ; so better vision when light intensity is low at night **[1]** ; cones cannot work when light intensity is low **[1]** ; more rods provide better vision in dim light **[1]** ;

Chapter 12 continued

9 a Two marks for the names, then any four of the other marks:

- **A** – vesicles containing neurotransmitter ;
- release neurotransmitter molecules ;
- into the synaptic gap ;
- which then diffuse across the gap ;
- **B** – receptor proteins ;
- have a complementary shape to the neurotransmitter molecules ;
- so, the neurotransmitter molecules can bind with them ;
- which sets off an electrical impulse in the right-hand neurone ; **[Max. 6]**

b aerobic respiration **[1]** ; releasing energy **[1]** ; for, transmission of the electrical impulses / synthesising neurotransmitter / moving the vesicles to the membrane **[1]** ;

Chapter 13

Science in context: Bird droppings

1 Possible suggestions include:
- keeping excretory products away from the developing chick in the egg
- conserving water, so they do not need to drink as much
- keeping weight down for flight, as they don't need to have as much liquid in their bodies to get rid of urine.

2 Reptiles, like birds, develop in an enclosed egg, so you would expect them to excrete a paste-like urine, and they do.

Questions

1 Excretion is the removal of the waste products of metabolism and substances in excess of requirements. Carbon dioxide is a waste product of respiration, which is a metabolic reaction.

2 Oxygen, which diffuses out of the leaves through the stomata.

3 liver, kidneys

4 Urine is a solution of urea and ions in water.

5 The ureters transfer urine from the kidneys to the bladder. The urethra transfers urine from the bladder to the outside of the body.

Activity 13.1

1 The brown structures are nuclei. There is no other structure that could be that large in a cell.

2 They are microvilli. They increase the surface area of the cell, to increase the rate of absorption, just like the microvilli on the surface of the villi in the small intestine.

Questions

6 The liver uses amino acids to synthesise proteins. These become part of the liver cells, or they may be released into the blood (as plasma proteins) and transported to other parts of the body, where cells make use of them.

7 Deamination is the removal of the nitrogen-containing part of excess amino acids. It happens in the liver.

8 a Glucose is a small molecule, which therefore passes through the filter from the glomerulus into the lumen of the nephron.

b All of the glucose is reabsorbed from the lumen of the nephron into the blood, before the filtrate reaches the ureters.

9 Being long and narrow increases the surface area that is in contact with the filtrate, and the time for which this contact is made (because it takes longer for the filtrate to flow through than if it was short). Having blood capillaries in close contact reduces diffusion distance.

10 They are made by an endocrine gland (the pancreas), are transported in the blood, and affect target organs (in this case, the liver).

11 a It begins at 85 mg per 100 cm^3 and does not change until 20 minutes after eating. It then rises until 1 hour 20 minutes after eating, to a maximum of 105 mg per 100 cm^3. It falls to a minimum of just below 80 mg per 100 cm^3 at 4 hours, and then rises to 85 mg per 100 cm^3 at 5 hours.

b It took time for the starch in the food to be digested by amylase and maltase producing glucose. The glucose then had to be absorbed.

Chapter 13 continued

c The pancreas detected the increased blood glucose concentration and responded to this by secreting insulin. Insulin was transferred to the liver in the blood, and the liver responded to the insulin by taking up glucose from the blood, using some in respiration and converting the rest to glycogen and storing it.
Also, body cells are constantly using glucose for respiration, which also causes the concentration in the blood to fall.

d As the blood glucose level fell below the set point, the pancreas detected this and secreted glucagon, which was transferred in the blood to the liver, which responded by breaking down glycogen and releasing glucose into the blood. This took time, during which the blood glucose concentration continued to fall.

12 Proteins are made by joining amino acids together on the ribosomes. Ribosomes are found on rough endoplasmic reticulum. The process requires energy, which is provided by aerobic respiration in mitochondria. As the islet cells in the pancreas make a lot of proteins, they need a lot of these structures.

13 All the glucose is reabsorbed from the filtrate as it flows through the nephron.

14 This sensor detects the actual concentration of glucose in the blood, and gives a precise reading for it. The dipstick only measures glucose in urine, which is an indirect way of finding out how much glucose there is in the blood, and in any case only tells you how much there was some time ago, when the urine was produced (rather than 'now'). So the first sensor is better because it gives a real-time, more accurate value.

15 It would be broken down to its constituent amino acids by proteases in the stomach and small intestine.

Exam-style questions

1 C ; **[1]**

2 B ; **[1]**

3 C ; **[1]**

4 D ; **[1]**

5 D ; **[1]**

6 **a** **i** by amylase **[1]** ; in the mouth **[1]** ; and in the small intestine **[1]** ;

ii small intestine / ileum ; **[1]**

b Any two from:

- the contents of the cells would be more dilute than the solution around them ;
- so, they would lose water by osmosis ;
- metabolic reactions in the cells cannot take place if they lose too much water ; **[Max. 2]**

c **i** pancreas ; **[1]**

ii reduces blood glucose concentration ; **[1]**

7 **a** A = cell membrane **[1]** ; B = nucleus **[1]** ;

b through the pancreatic duct **[1]** ; in pancreatic juice **[1]** ; to the duodenum **[1]** ;

c in the blood **[1]** ; dissolved in the plasma **[1]** ; to all parts of the body / to the liver **[1]** ;

Chapter 13 continued

8 a for respiration **[1]** ; which supplies energy **[1]** ; for any named process (e.g. active transport, movement) **[1]** ;

b pancreas ; **[1]**

c i starch broken down to glucose **[1]** ; by amylase and maltase **[1]** ; absorbed into the blood from the ileum **[1]** ;

ii used by cells for respiration **[1]** ; insulin secreted **[1]** ; which causes the liver to take up glucose **[1]** ; glucose stored in the liver as glycogen **[1]** ;

d sensors in pancreas detect blood glucose concentration **[1]** ; if it is too high, insulin is secreted and brings the concentration down **[1]** ; if it is too low, glucagon is secreted and increases the concentration **[1]** ;

e i curve rises at same time as original curve **[1]** ; to a higher level **[1]** ; remains high for longer **[1]** ;

ii rises to a higher level / stays high for longer, because no insulin is secreted **[1]** ; only cellular respiration removes glucose from the blood **[1]** ;

9 a A: 37.4 °C **[1]** ; B: 37.5 °C **[1]** ;

b Any four from:

- homeostasis ;
- humans are endothermic / keep a constant body temperature ;
- body produces more heat to maintain body temperature ;
- reference to shivering ;
- reference to vasoconstriction ;

[Max. 4]

c Any two from:

- air is more insulating than water ;
- heat lost more easily from the body in water than in air ;
- by conduction ; **[Max. 2]**

d Any three from:

- person A was moving but person B remained still ;
- idea that 'new' cold water was constantly coming into contact with A's skin ;
- water around B's body warms up (as heat is lost from his body to the water) ;
- heat transfers from hot object to colder object; so, more heat lost from A's body than B's body ; **[Max. 3]**

Chapter 14

Questions

1 14

2 a 14

b 28

3 Meiosis halves the chromosome number, to produce gametes. The male gametes of a flowering plant are produced inside the pollen grains, in the anthers. In the root, new cells need to have the full diploid number, just like the cells that divide to form them, so mitosis is the appropriate type of cell division.

4 The flower has brightly coloured petals, to attract insects. The petals have guide-lines, to guide the insect to the centre of the flower. The anthers and stigma are within the petals, which are arranged so that the insect has to brush past them to reach the nectar in the base of the flower.

5 a The anthers dangle out of the flower, so that the stamens can swing in the wind and release their pollen. The stigmas are feathery and stick out of the flower, so that they can easily catch pollen blowing on the wind. There are no petals to obstruct the wind.

b Wind-pollinated flowers produce much more pollen than insect-pollinated flowers. Their pollen is also much lighter, so it is more likely to be floating in the air, where it can be breathed in by a person.

Experimental skills 14.1

1 Water: to provide a solvent in which substances in the cells can dissolve, so that metabolic reactions can take place.
Oxygen: for aerobic respiration, to release energy from glucose to drive energy-requiring metabolic reactions, or for active transport.
A warm temperature: to ensure that reacting molecules, and enzymes catalysing their reactions, have sufficient kinetic energy to collide frequently.

2 If they germinated when there was only a little light, they would not be able to photosynthesise once they have grown into plants with leaves, and would die. Waiting for a tree to fall, letting light into the forest floor, means that they have a better chance of obtaining light and being able to grow successfully.

Questions

6 C, A, B

7 a Asexual reproduction. She wants the new plants to have exactly the same characteristics as the original plant, which is most likely to happen if there is no genetic variation. Even if she is able to self-pollinate the flowers on the single plant she has, the resulting seeds could still have different combinations of alleles, which could mean they do not all grow into plants that produce red flowers.

b Sexual reproduction. She has a population of plants that have genetic variation among them, which is why they all have slightly different colours of flowers. If she interbreeds them, the resulting seeds could have even more different combinations of alleles, which could produce different colours.

c Either asexual or sexual reproduction. Almost all of her plants are being killed by the fungus – but some are not. These plants may have alleles that provide resistance to the fungus. She could use these surviving plants and produce more plants from them asexually, which should all be genetically identical to their parents and not be killed by the fungus. Alternatively, she could try breeding some of the resistant plants with each other, or even with the non-resistant ones, to produce a new strain of resistant plants.

Chapter 14 continued

Exam-style questions

1 B ; [1]

2 A ; [1]

3 C ; [1]

4 A ; [1]

5 C ; [1]

6 a gamete ; [1]

b zygote ; [1]

c pollination ; [1]

d seed ; [1]

e fertilisation ; [1]

7 a

Tube	A	B	C	D	E
Water	✗	✓	✓	✓	✓
Oxygen	✓	✓	✗	✓	✓
Warm temperature	✓	✓	✓	✓	✗
Light	✓	✓	✓	✗	✓

all correct for two marks, with one mistake one mark, with two mistakes no marks ; **[2]**

b B **[1]** ; D **[1]** ;

c i a male nucleus from a pollen grain **[1]** ; fuses with a female nucleus from an ovule **[1]** ;

ii ovule ; **[1]**

8 a asexual ; **[1]**

b produces new banana plants that are identical to the parent (so the bananas will be exactly the same variety) **[1]** ; predictable yields / flavour / other named attribute **[1]** ;

c all new plants will be genetically identical **[1]** ; if the parent did not have resistance to the disease then nor will the offspring **[1]** ;

9 a pin-eyed has stigma above anthers **[1]**; thrum-eyed has anthers above stigma **[1]**;

b i thorax ; **[1]**

ii abdomen ; **[1]**

c i abdomen ; **[1]**

ii thorax ; **[1]**

d cross-pollination means pollination between two different flowers **[1]** ; pollen picked up from one part of the body in one type of flower will be deposited on the anthers of the other type of flower **[1]** ; pin-eyed flower unlikely to have pollen from another pin-eyed flower deposited on its stigma / same idea for thrum-eyed **[1]** ;

e thrum-eyed **[1]** ; pollen can fall from anthers down onto stigma **[1]** ;

f Any two from:

- offspring show genetic variation ;
- not all individuals will be vulnerable to the same diseases / some may survive a disease ;
- different individuals may survive better in different environments ;
- species may be able to survive environmental change ; **[Max. 2]**

Chapter 15

Questions

1 Eggs: in follicles, in ovaries.
Sperm: in the tubules in a testis.

2 a the prostate gland

b an oviduct

c the lining of the uterus

3 For example:

Eggs	Sperm	Explanation
haploid	haploid	at fertilisation, a diploid zygote is formed
relatively large cell	a small cell	eggs need to be large to provide space for stored nutrients; sperm need to be small to reduce the energy required for swimming
contains stored nutrients	no stored nutrients	the nutrients in an egg provide for the zygote and embryo before implantation; sperm use nutrients in semen (secreted by the prostate gland)
has a jelly coat	no need for a jelly coat	prevents entry of more than one sperm
does not have a flagellum	has a flagellum, containing many mitochondria	requires energy for swimming, provided by aerobic respiration in mitochondria; flagellum provides propulsion
does not have an acrosome	has an acrosome, containing digestive enzymes	enzymes make a pathway into the egg, for the sperm head to enter

4 Eggs are moved by the cilia and muscles in the wall of the oviducts – they do not move themselves. In contrast, sperm swim actively, lashing their flagella.

5 An embryo is a ball of undifferentiated cells, formed by repeated division of the zygote. A fetus develops from an embryo when the cells have formed different tissues and organs.

6 oxygen, glucose, amino acids, fatty acids, glycerol, minerals (or named minerals), vitamins (or named vitamins), water

7 carbon dioxide and urea

8 Small intestine (duodenum and ileum); this is where absorption of digested nutrients takes place. Villi in both this location and the placenta provide a large surface area, which increases the rate at which materials can transfer across it.

9 Testosterone stimulates sperm production, causes facial and pubic hair to develop, causes shoulders to broaden and the voice to break. Oestrogen causes pubic hair to develop, causes the breasts to develop and the hips to broaden; it also helps to control the menstrual cycle.

10 a An egg is developing in a follicle.

b The egg continues to develop.

c The follicle from which the egg was released has changed into a corpus luteum, and is secreting progesterone.

11 a Progesterone causes the lining to remain thick, with a good blood supply.

b This ensures that the lining is ready for an embryo to implant, if an egg is fertilised.

c It secretes progesterone, which maintains the uterus lining.

d If the egg is fertilised, the corpus luteum continues to secrete progesterone, until the placenta has developed and takes over this role. If the egg is not fertilised, the corpus luteum breaks down, progesterone secretion stops, and the uterine lining breaks down and is lost through the vagina.

Chapter 15 continued

Exam-style questions

1 B ; [1]

2 C ; [1]

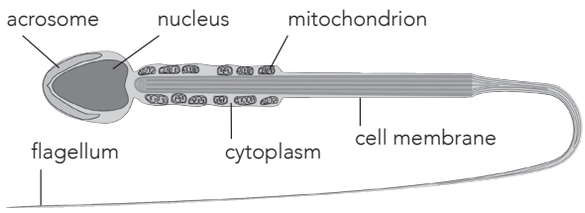
3 A ; [1]

4 C ; [1]

5 D ; [1]

6 testes **[1]** ; sperm ducts **[1]** ; urethra **[1]** ; prostate **[1]** ; testosterone **[1]** ; sperm **[1]** ; secondary **[1]** ;

7 a One mark for any two correct ;



[3]

b haploid nucleus, to produce a diploid zygote when it fuses with an egg nucleus **[1]** ; acrosome containing digestive enzymes, to make a pathway into the egg for the head of the sperm **[1]** ; long flagellum for propulsion to the egg **[1]** ; many mitochondria to release energy by aerobic respiration, for swimming **[1]** ;

c haploid nucleus, to produce a diploid zygote when it fuses with a sperm nucleus **[1]** ; food stores to provide for zygote and embryo until implantation **[1]** ; jelly coat to prevent entry of more than one sperm **[1]** ;

8 a ovary ; [1]

b i lining breaks down and is lost for about first five days **[1]** ; lining builds up over the next ten days or so **[1]** ;

ii egg is developing inside a follicle **[1]** ; ovulation on day 14 **[1]** ;

c ensures the uterus lining remains thick **[1]** ; ready for the implantation of an embryo (if the egg is fertilised) **[1]** ;

9 a increases from 1990 to 1999 **[1]** ; falls from 1999 to 2017 **[1]** ; change in figures quoted, e.g. from 2 million in 1990 to 3.2 million in 1999 **[1]** ;

b HIV infection does not produce symptoms immediately **[1]** ; people can be infected and not know **[1]** ;

c HIV enters, white blood cells / lymphocytes **[1]** ; destroys them / reduces their numbers **[1]** ; so immune system cannot attack, pathogens / cancerous cells, successfully **[1]** ; allowing other infections to develop **[1]** ; increasing risk of cancer developing **[1]** ;

d number of people living with HIV/AIDS is increasing, but number of deaths from HIV/AIDS is decreasing **[1]** ; comparative figures quoted **[1]** ; use of antiretrovirals **[1]** ; allows people to live normal lives even when infected **[1]** ; prevents AIDS developing after HIV infection **[1]** ;

Chapter 16

Questions

1 nucleus

2 gene; DNA molecule; chromosome; nucleus; cell

3 We all have the same *genes*, but we have different combinations of *alleles* of those genes.

4 32

5 This is so that, when the cell divides by mitosis, each daughter cell gets an identical set of alleles – so that the new cells are genetically identical. This is what is required for growth, repair of damaged tissues, replacement of cells and for asexual reproduction.

6 With 46 chromosomes in the cell, there is a lot of potential for them getting tangled up together. By keeping the two identical copies together, it becomes easier for them to separate in an orderly way as the cell divides.

7 The new cells produced have a reduced number of chromosomes, compared with the parent cell.

8 14

9 Diploid cells in an organism's body divide by meiosis to produce gametes with a single set of chromosomes. When two gametes fuse together, the zygote has two sets. The zygote can then divide by mitosis, producing cells that continue to divide, over and over again, by mitosis, making all the diploid cells that form the adult's body.

10 a Any upper case and lower case letter – e.g. **B** for brown eyes and **b** for green eyes.

b **BB** brown, **Bb** brown and **bb** green

c **BB** and **bb** are homozygous and **Bb** is heterozygous.

11 The allele for round leaves is dominant, because this is the phenotype shown by a heterozygous plant.

12 For letters like S or C, it is difficult to tell the upper and lower case (capital and small) letters apart. For letters like A or B, it is easy to tell the upper and lower case letters apart.

13 a For example: $\mathbf{H^R}$ for the red hair allele and $\mathbf{H^W}$ for the white hair allele.

b genotype $\mathbf{H^RH^R}$ gives red hair; genotype $\mathbf{H^RH^W}$ gives roan hair; genotype $\mathbf{H^WH^W}$ gives white hair

14 Allele $\mathbf{I^A}$ and allele $\mathbf{I^B}$ are both dominant to allele $\mathbf{I^o}$. If either of these dominant alleles is present, allele $\mathbf{I^o}$ has no effect on the phenotype. But alleles $\mathbf{I^A}$ and $\mathbf{I^B}$ are codominant. When they are both present, they both affect the phenotype.

15 a **T**

b **T** and **t**

c **t**

16 **TT**

17 **Tt**

18 **TT** and **Tt**

Activity 16.2

1 Answers will depend on what was used for the 'alleles', and how the learners did their experiment. For example, perhaps the learners did not pick out the different beads randomly – maybe one bead was larger than the other, and more likely to be picked up.

Questions

19 a **NN** normal wings, **Nn** normal wings, **nn** vestigial wings

b

Parents' phenotypes	normal wings	normal wings
Parents' genotypes	**NN**	**Nn**
Gametes	(N)	(N) (n)
Offspring genotypes and phenotypes	(N)	(n)
(N)	**NN** normal wings	**Nn** normal wings

All the offspring would have normal wings.

Chapter 16 continued

20

Parents' phenotypes	brown hair	brown hair
Parents' genotypes	**Bb**	**Bb**
Gametes	(B) (b)	(B) (b)
Offspring genotypes and phenotypes	(B)	(b)
(B)	**BB** brown hair	**Bb** brown hair
(b)	**Bb** brown hair	**bb** red hair

If both parents were heterozygous, then both can produce gametes containing the **b** alleles. If two such gametes fuse to form a zygote, the resulting offspring will have the genotype **bb** and have red hair. The chance of this happening is one in four each time they have an offspring. By chance, this has happened three times out of five.

21 If the parents have a child with blood group O, then they must each have allele $\mathbf{I^o}$.

Parents' phenotypes	group A	group B
Parents' genotypes	$\mathbf{I^AI^o}$	$\mathbf{I^BI^o}$
Gametes	(I^A) (I^o)	(I^B) (I^o)
Offspring genotypes and phenotypes	(I^B)	(I^o)
(I^A)	$\mathbf{I^AI^B}$ group AB	$\mathbf{I^AI^o}$ group A
(I^o)	$\mathbf{I^BI^o}$ group B	$\mathbf{I^oI^o}$ group O

22 Person 1 (male) has a child with blood group O, so he must have the allele $\mathbf{I^o}$. His genotype is therefore $\mathbf{I^AI^o}$.
Person 2 (male) is married to person 3 (female) who is blood group B. One of their children has blood group AB so person 2 must have at least one $\mathbf{I^A}$ allele. Their other child has blood group O so must be genotype $\mathbf{I^oI^o}$ having inherited an $\mathbf{I^o}$ allele from each parent. So, person 2 must be genotype $\mathbf{I^AI^o}$ and have blood group A.

23 One in two. The sex of the previous children does not affect the chances of what the next one will be. Each time, the chances are the same.

24 a

Parents' phenotypes	colour-blind man	woman with normal vision
Parents' genotypes	$\mathbf{X^bY}$	$\mathbf{X^BX^b}$
Gametes	(X^b) (Y)	(X^B) (X^b)
Offspring genotypes and phenotypes	(X^B)	(X^b)
(X^b)	$\mathbf{X^BX^b}$ girl with normal vision	$\mathbf{X^bX^b}$ colour-blind girl
(Y)	$\mathbf{X^BY}$ boy with normal vision	$\mathbf{X^bY}$ colour-blind boy

There is a one in four chance that any child will be a colour-blind boy. There is also a one in four chance of a colour-blind girl, but this has not happened.

b one in four (25%)

Exam-style questions

1 B ; [1]

2 B ; [1]

3 A ; [1]

4 B ; [1]

5 D ; [1]

6 **a** heterozygous ; [1]

b pure-breeding ; [1]

c phenotype ; [1]

d recessive ; [1]

e allele ; [1]

Chapter 16 continued

7 **a** **i** **ee** ; **[1]**

ii **EE** ; **[1]**

b parent's genotypes **Ee** **Ee** **[1]** ;
gamete genotypes **E** and **e** **E** and **e** **[1]** ;

	E	e
E	**EE** indented	**Ee** indented
e	**Ee** indented	**ee** smooth

[5]

all offspring genotypes correct **[1]** ;
phenotypes correctly matched to genotypes **[1]** ;
expected ratio of 3 : 1 indented to smooth matched to actual numbers of 99 : 302 **[1]** ;

8 **a** $\mathbf{C^BC^B}$ black feathers;
$\mathbf{C^BC^W}$ grey feathers;
$\mathbf{C^WC^W}$ white feathers;
(two correct for one mark, all correct for two marks) **[Max. 2]**

b they are codominant **[1]** ; capital letter would be used to represent a dominant allele and small letter for a recessive allele **[1]** ;

c parents' genotypes correct **[1]** ; all gametes correct and shown inside circles **[1]** ; genotypes of offspring correct (could be in a Punnett square) **[1]** ; phenotypes of offspring correctly associated with genotypes **[1]** ; would expect, 1 : 1 grey : white / 50% grey and 50% white offspring **[1]** ;

9 **a** there are four colour-blind males but only one colour-blind female **[1]** ; the male who marries out of the family does not have colour-blind sons **[1]** ;

b
- person 2 $\mathbf{X^bX^b}$ **[1]** ;
- person 3 $\mathbf{X^bY}$ **[1]** ;
- person 11 $\mathbf{X^BX^b}$ **[1]** ;
- person 13 $\mathbf{X^bY}$ **[1]** ;
- person 19 $\mathbf{X^BY}$ **[1]** ;

c parents' genotypes correct **[1]** ; all gametes correct and shown inside circles **[1]** (could be in a Punnett square – see below) ; genotypes of offspring correct **[1]** ; phenotypes of offspring correctly associated with genotypes **[1]** ; 50 : 50 / one in two, chance that any son will be colour-blind **[1]** ;

	X^B	X^b
X^b	$\mathbf{X^BX^b}$ carrier female	$\mathbf{X^bX^b}$ colour-blind female
Y	$\mathbf{X^BY}$ male with normal vision	$\mathbf{X^bY}$ colour-blind male

d the allele for colour blindness is on the X chromosome **[1]** ; man passes on a Y chromosome to his sons **[1]** ;

Chapter 17

Experimental skills 17.1

1 and 2 These answers will depend on the learners' results.

3 Learners should recognise that finger length could be affected by both genes and the environment. Possibly genes could determine the maximum length to which fingers can grow, while environment could affect whether or not they reach this potential length.

Questions

1 a discontinuous

b continuous

c continuous

d discontinuous

2 a genes alone

b genes and environment

c genes and environment

d genes alone

3 a discontinuous

b It is caused entirely by genes. The recessive allele codes for green seeds – call it **g**. The dominant allele codes for yellow seeds – **G**. Seeds with the genotype **gg** are green and are therefore homozygous and pure-breeding. Yellow seeds can be heterozygous, **Gg**, and can therefore produce some yellow seeds when they are crossed.

4 a discontinuous

b It is approximately 3 : 1. Note that some learners may see that there are some dark brown kernels and some light brown ones, and not be sure whether to count these as brown or white. Accept either interpretation.

c If learners consider that all the brown kernels are the same, then they are likely to suggest that the allele for white is dominant, and the allele for brown is recessive. Accept any symbols that use upper case for white and lower case of the same letter for brown – for example **B** and **b**. The parents could have had the genotypes **Bb** and **Bb**, which would give a 3 : 1 ratio of white : brown in the offspring phenotypes.

If learners consider that the light brown kernels are different from the dark brown ones, they may suggest that this is an example of codominance. In that case, their symbols for the alleles should use a capital letter to represent the gene, and superscripts for the alleles. Suitable symbols could be $\mathbf{C^W}$ for white and $\mathbf{C^B}$ for brown. It is, however, not then possible to suggest a cross that would produce the ratios shown on the cob.

5 a By mutation. (Learners studying the supplement will probably give a more extended response and explain that mutation is a random change in the base sequence of DNA.)

b mutation, meiosis, random mating and random fertilisation

6 For example:

- large eyes, to capture as much light as possible, which will help the tarsier to see in the dark to help it to find insects, and to escape predators
- long fingers, to help it to grip branches, and to capture and hold its prey
- large ears, to help it to detect insects by sound, and to hear approaching predators.

7 Different species of xerophytes and hydrophytes vary quite considerably, so learners' tables are likely to reflect the ones that they have seen and studied. Features that they may compare include:

- leaves – generally very small in xerophytes (may be reduced to spines); larger in hydrophytes, where they may be broad (where the plant's leaves are above water) or feathery (if they are under water)
- waxy cuticle – thick in xerophytes; thinner in hydrophytes
- stomata – on underside of leaves in xerophytes; on upper surface or both surfaces in hydrophytes. Tend to close in xerophytes when conditions are hot and dry; rarely close in hydrophytes.

Chapter 17 continued

8 1 Variation – In the peppered moth population, most peppered moths were pale but a few were dark; 2 Overproduction – Peppered moths produce many offspring, most of which do not survive. Only a small proportion survive long enough to reproduce; 3 Best-adapted individuals more likely to survive and reproduce – When the environment is polluted, dark moths are better camouflaged than pale ones on tree trunks. The pale moths are more likely to be eaten by birds, while the dark ones have a better chance of evading capture, surviving and reproducing; 4 Alleles that confer useful adaptations more likely to be passed on – The allele for dark wings is therefore more likely to be passed on to the next generation than the allele for pale wings.

9 With less air pollution, more lichen grows on tree trunks. Now the pale moths are better camouflaged than dark moths, so they are more likely to survive, reproduce and pass on their alleles for pale wings. Over time, the pale wing allele gradually becomes the most common one in the population of peppered moths, so most moths now have pale wings and few have dark wings.

10 The breeder should measure the methane output of all the sheep. Select a female and a male with low methane output and breed them together. Measure the methane output of the lambs and select a male and a female with the lowest methane output to breed together. Continue for many generations.

11 **a** Choose an individual wheat plant from a variety that has some resistance to rust, and another that has high yield. Transfer pollen from one to the stigma of the other. Collect the seeds and sow them and grow the plants to their full size. Expose them all to rust, and select those that are most resistant, and that have the highest yield, to breed. Continue for many generations. You could also bring in new individuals at some stage, for example a different high-yielding parent could be used to breed with the best rust-resistant offspring in generation 2 or 3.

b The rust undergoes natural selection. There will be variation among the rust individuals, and some may have alleles that allow them to infect the resistant wheat plants. These individuals have a selective advantage – they are more likely to survive and reproduce, as they have access to more food than the rust individuals that can only grow on non-resistant wheat plants. The alleles for the ability to infect resistant wheat plants are therefore more likely to be passed on to the next generation of rust fungus. Over time, more and more rust fungi in a population are likely to have these alleles and be able to infect previously resistant wheat plants.

Exam-style questions

1 B ; **[1]**

2 D ; **[1]**

3 D ; **[1]**

4 C ; **[1]**

5 B ; **[1]**

6 species **[1]** ; discontinuous **[1]** ; genes **[1]** ; continuous **[1]** ; mutation **[1]** ; adapted **[1]** ;

7 **a** mean milk yield increased **[1]** ; no change in the first two years **[1]** ; relatively steady change from then on **[1]** ; total change is 366 kg per cow **[1]** ;

b select cows that produce most milk and bulls whose female relatives produce most milk **[1]** ; breed them together **[1]** ; select offspring that produce most milk **[1]** ; repeat for many generations **[1]** ;

c breeder can simply choose animals that produce most milk **[1]** ; selection is done on phenotype, not genotype **[1]** ;

d breeder was not selecting for protein content / perhaps cows that produce more milk have always had less protein in their milk ; **[1]**

Chapter 17 continued

8 a they rise and then fall **[1]** ; maximum number is in 2006 **[1]** ; overall change is from about 40 cases in 1993 to about 260 cases in 2012 **[1]** ;

b 1650 cases out of 2150 = 76.7%
[2 marks for correct answer]

c Any two pairs for two marks each:

- reducing use of antibiotics – reduces selection pressure on the bacteria ;
- better hygiene when treating patients / description of this (e.g. washing hands more carefully after touching one patient before touching another) – avoiding transmission of bacterium between individuals ;
- finding new antibiotics that kill MRSA – so, people infected with it less likely to die ;

(allow other suitable and biologically correct suggestions) ; **[Max. 4]**

9 a change in base sequence in DNA **[1]** ; random **[1]** ;

b ionising radiation / named example of ionising radiation **[1]** ; chemicals / named mutagenic chemical **[1]** ;

c Any three from:

- change in base sequence in DNA causes change in amino acid sequence in the protein that is synthesised ;
- so, structure of the protein is different ;
- so, function of the protein is different ;
- example – e.g. shape of active site of protein is no longer complementary to substrate ; **[Max. 3]**

d random mating / any male can mate with any female **[1]** ; so, alleles from any male can be combined with those from any female **[1]** ; meiosis **[1]** ; produces gametes with different combinations of alleles **[1]** ; random fertilisation / any male gamete can fuse with any female gamete **[1]** ; so, alleles from any of the male's gametes can be combined with those from any of the female's gametes **[1]** ;

Chapter 18

Questions

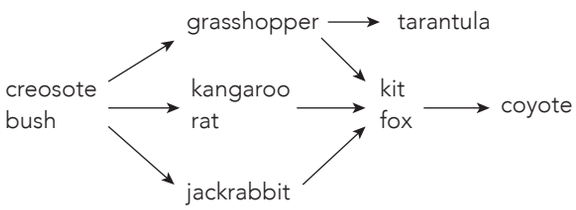
1 **a** creosote bush → kangaroo rat → kit fox → coyote

b creosote bush

c Primary consumer: kangaroo rat
Secondary consumer: kit fox
Tertiary consumer: coyote

d Kangaroo rats are herbivores. Kit foxes and coyotes are carnivores.

e



2 Look for a correct and plausible food chain, with arrows in the correct direction. Producer, primary consumer, secondary consumer and so on should be correctly labelled.

3 Energy is lost to the environment as it is passed along a food chain. By the time it reaches the fifth step in a food chain, there is not enough to support a population of consumers at this level.

Questions

4 It means that the relative sizes of the bars in the pyramid may be completely wrong, because the information that we are using to construct it is incomplete. For example, if kangaroo rats eat other plants, then we should include all of those in the diagram. If other herbivores eat these plants, then we should also include those.

5 The pyramid should look similar to the diagram in Figure 18.11.

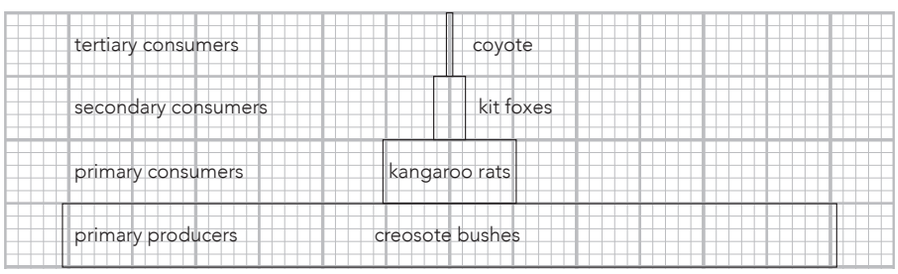
6 People can eat soya beans. A great deal of energy is lost as it is transferred from soya beans to cattle, so humans get less energy than they would have done by eating the soya directly. (Some learners may also appreciate the high energy costs of transporting the soya beans to this area, and also supplying water to the cattle in a desert region.)

7 **a** Photosynthesis removes carbon dioxide from the air.

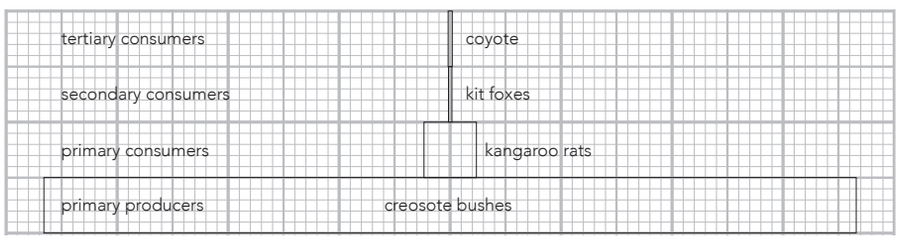
b Respiration and combustion add carbon dioxide to the air.

Activity 18.2

Task 1



Task 2



Chapter 18 continued

8 For example: The lion dies. Its body is decomposed, and some of the carbon atoms in it become part of the decomposers. They respire, and some of the carbon atoms return to the air as carbon dioxide. This is taken into a grass plant and used in photosynthesis to make glucose in the plant cells.

9 **a** Nitrogen fixation converts inert nitrogen gas, which most organisms cannot use, into more reactive ammonium or nitrate ions, which they can use.

b Nitrification converts ammonia into nitrate, which plants can absorb and use to make amino acids and proteins.

10 Nitrogen fixation: nitrogen-fixing bacteria in root nodules or the soil convert inert nitrogen into more reactive forms.
Nitrification: nitrifying bacteria in the soil convert ammonia into nitrate.
Denitrification: denitrifying bacteria, especially in waterlogged soils, convert nitrate into nitrogen gas.
Decomposition: decomposers convert dead bodies and organic waste material to ammonia.

11 Deamination happens in the liver of animals. It converts excess amino acids to urea.

12 In a waterlogged soil, there is very little nitrate, because most is converted to nitrogen gas and lost to the air. Carnivorous plants can get nitrogen in a similar way to animals, by digesting proteins in insects to amino acids and absorbing them. These plants are not able to compete with 'normal' plants in soils where there is plenty of nitrate, as they do not have adaptive features that allow them to grow as well in those conditions.

13 A population is all the organisms *of one species* that live in the same place at the same time, but a community is all the organisms *of every species* that live in the same place at the same time.

14 food supply, predation and disease

15 The left-hand axis, for hares, goes up to 160 000. The right-hand axis, for lynx, only goes up to 6000. This is because energy is lost along the food chain, so the total quantity of energy available to support a lynx population is less than is available to support the snowshoe hare population.

Exam-style questions

1 B ; **[1]**

2 A ; **[1]**

3 D ; **[1]**

4 A ; **[1]**

5 C ; **[1]**

6 **a** the transfer of energy **[1]**

b grass / ladysmock **[1]**

c ladysmock → caterpillar → robin → kestrel
or
ladysmock → caterpillar → short-tailed field vole → kestrel
or
ladysmock → caterpillar → short-tailed field vole → fox
one mark for the organisms, one mark for the arrows ; **[2]**

d less grass eaten by voles **[1]** ; so, more food for rabbits and their population increases **[1]** ; fewer voles for foxes to eat **[1]** ; so, foxes eat more rabbits and the rabbit population decreases **[1]** ;

7 **a** Approximately 0.04% of the air is carbon dioxide. This gas diffuses into plants through their stomata and is used to make glucose in the process of photosynthesis. Animals eat plants, and some of the carbon atoms in the glucose become part of molecules such as glycogen in their bodies. When the animals die, their bodies are broken down by decomposers. Plants, animals and decomposers return carbon dioxide to the air through respiration. **[6]**

Chapter 18 continued

b dead plants / microorganisms / organisms are not fully decomposed **[1]** ; buried deep in the Earth **[1]** ; subjected to high pressure / high temperatures **[1]** ; carbon returned to air as carbon dioxide when they undergo combustion **[1]** ;

8 a three bars stacked centrally on one another **[1]** ; widest bar at the bottom **[1]** ; middle bar a little smaller than the bottom bar, and the top bar much smaller than the middle bar **[1]** ; each bar correctly labelled as producers, herbivores or carnivores, with the numbers 22 000, 7 009 and 4 respectively **[1]** ;

b quantity of energy within each individual organism is not the same in each type **[1]** ; there may be other organisms in the food web that are not included in this table **[1]** ;

c energy is lost as it is transferred along a food chain **[1]** ; by respiration / heat lost to the environment **[1]** ; not all organisms / not all parts of organisms, eaten by the next trophic level **[1]** ; not as much energy to support carnivores as there is to support herbivores **[1]** ;

9 a carbon, hydrogen and oxygen ; **[1]**

b Any six (in a suitable sequence) from:

- nitrogen fixation by, lightning / bacteria ;
- produces nitrate ions;
- taken up through the root hairs of plants ;
- used to make amino acids / proteins;
- human eats the plant ;
- proteins digested to amino acids ;
- absorbed from the small intestine and taken up into cells ;
- used to make proteins on ribosomes ;

[Max. 6]

c i axes the right way round: i.e. time on the *x*-axis and number of plants on the *y*-axis **[1]** ; *x*-axis labelled: time **and** *y*-axis labelled: number of plants (no need for scales) **[1]** ; S-shaped curve drawn (no need for scales) **[1]** ; no death phase included **[1]** ; log, lag and stationary phase labelled **[1]** ;

ii shortage of nitrate ions is a limiting factor **[1]** ; reducing the rate of population growth **[1]** ;

Chapter 19

Questions

1 a fertilisers

b herbicides

c selective breeding

d agricultural machinery

e insecticides

2 a Farmers can use machinery to cultivate large areas of land in the same way at the same time, increasing efficiency. They can use the same pesticides and/or herbicides over the whole crop. They can harvest the crop efficiently, because all the plants will ripen at the same time and be a similar size.

b They reduce biodiversity, because the variety of habitats that would otherwise be available is lost. They allow the populations of some species (e.g. insect pests) to become very large. They disrupt natural food webs.

3 For example:
Welfare issues: chickens may be stressed, and disease is more likely to spread.
Pollution: large quantities of waste from the chickens is concentrated in a small area and may pollute the surrounding land and waterways.
Large inputs are needed: chickens need to feed on food that is given to them, rather than foraging naturally, and provided with water that must be transported to the farming area. The chickens' food might be made from food that we could eat ourselves. Transporting food has energy costs.

4 Each species has adaptive features that increase its ability to survive and reproduce in its habitat. If that habitat is destroyed, the species may not be able to survive and reproduce in another habitat.

5 Coral reefs and rainforests provide a very wide variety of different habitats, which means that many different species can live there. A monoculture provides a very narrow range of habitats, so only a few species can live there.

6 Habitat loss; risk of extinction of plant and animal species; increased soil erosion; increased risk of flooding; increased carbon dioxide concentration in the air; decreased transpiration so less water vapour in the air.

7 The greenhouse effect is a natural and necessary phenomenon; carbon dioxide in the atmosphere traps infrared radiation from the Earth's surface, which keeps the Earth warmer than it would otherwise be. This is essential for life.
The enhanced greenhouse effect is a result of increased concentrations of carbon dioxide and methane in the atmosphere, which traps more infrared radiation and makes the Earth even warmer.
Climate change is a result of the increase in the mean temperature on Earth, caused by the enhanced greenhouse effect. It involves long-term changes in weather patterns, including changes in the times and intensity of rainfall, and increases in extreme weather events.

8 a This could reduce the amount of carbon dioxide emitted in car exhausts.

b This could reduce the time cars and trucks are on the road, reducing the emissions of carbon dioxide from their exhausts.

c This could reduce the amount of fuel that is burnt, either in the home itself or in power stations generating electricity that is used for heating the home. Burning fuels produces carbon dioxide.

d This could reduce the amount of fossil fuel that is burnt in power stations. Nuclear power stations do not produce carbon dioxide.

e This could reduce the amount of fuel used in factories where the materials in the rubbish are made, or in the generation of electricity to supply these factories.

9 untreated sewage, fertilisers (containing nitrate ions)

Chapter 19 continued

10 a not able to be broken down by decomposers or other living organisms

b They remain in the environment for a very long time. Plastics discarded at sea, or carried into the sea by rivers, can be carried over large distances and be washed up shores a long way from the point of disposal. Biodegradable substances break down, and do not persist in the environment for very long.

11 a The curve for bacteria shows a high level at the point at which the untreated sewage is discharged. The sewage contains nutrients that the bacteria can feed on, so their population is high. As you go downstream, the quantity of nutrients decreases because the bacteria have been using them up, so the population of bacteria also decreases.

b The quantity of dissolved oxygen is affected by the population of bacteria. The bacteria respire aerobically, taking oxygen from the water, so the quantity of oxygen in the water just downstream from where their population is highest drops. As the bacterial population falls, oxygen levels begin to rise again.

c Fish are absent from the area where the untreated sewage enters the stream, and only appear some distance downstream. They are affected by the oxygen levels in the water. They are unable to live in the parts of the stream where levels of aerobic bacteria are high, because there is not enough oxygen for the fish to respire aerobically. They are only found in the areas where the oxygen levels are rising, and their largest population is found where the oxygen level is highest.

12 climate change; habitat destruction; hunting; pollution; introduced species (some learners may also have other suitable suggestions)

13 The new species may be a predator of some of the native species, or it may compete with them for scarce resources such as food or nesting sites.

14 Captive breeding is breeding animals in captivity, such as in zoos. If the captive breeding programme is successful, numbers of the endangered species can be increased. Eventually, it may be possible to return some of them to the wild.

15 Genetic diversity increases the chances that a population of organisms will be able to adapt to changes in their environment, such as climate change. It also reduces the chances of two harmful recessive alleles being brought together in the offspring of a breeding pair.

Exam-style questions

1 C ; **[1]**

2 B ; **[1]**

3 A ; **[1]**

4 C ; **[1]**

5 B ; **[1]**

6 biodiversity **[1]** ; carbon dioxide **[1]** ; endangered **[1]** ; greenhouse effect **[1]** ; erosion **[1]** ;

7 a likely to become extinct ; **[1]**

b Any five from:

- loss of habitat ;
- people use sandy beaches for pleasure ;
- pollution (of the sea or beach) ;
- (pollution) could reduce food supply / poison the turtles / increase risk of disease ;
- climate change ;
- causing sea level rise so beaches now covered by water ;
- turtles do not begin to breed until they are 30 years old ;
- so unable to quickly increase the population if it starts to fall ;
- alternative valid points ; **[Max. 5]**

Chapter 19 continued

c Any three from:

- increase death rate ;
- non-biodegradable plastics do not break down ;
- remain in the turtles' digestive system ;
- cause illness / blockage / prevent absorption of nutrients from food ;

[Max. 3]

8 a *Lynx* **[1]**

b Any two from:

- deforestation ;
- use of land for mining ;
- use of land for building roads ;
- use of land for building homes / factories ;
- pollution ;

[Max. 2]

(accept any two reasonable suggestions)

c i so that proper care can be provided **[1]** ; example of suitable care, for example, providing a suitable place to give birth / isolating from other animals / providing suitable food **[1]** ;

ii Any three from:

- idea that you cannot tell she is pregnant until the 5th / 6th week of pregnancy ;
- concentration of PGFM rises at week 5 ;
- can predict birth as likely to take place three weeks after the rise begins ;
- can predict birth as likely to take place when the level reaches 1.4 arbitrary units ;

[Max. 3]

iii Any three from:

- to prevent closely related animals breeding together ;
- to maintain genetic diversity ;
- which reduces chances of harmful recessive alleles coming together in offspring ;
- increases ability of the population to adapt to changes in their environment ;

[Max. 3]

9 a store seeds (in controlled conditions) for long periods of time **[1]** ; maintain a population of a species that is threatened in the wild **[1]** ; some (stored) seeds germinated to provide fresh seeds **[1]** ; collect seeds from different places to ensure genetic diversity **[1]** ; maintain / increase, genetic diversity by breeding individuals with different alleles together (to produce more seeds for storage) **[1]** ; if habitat is restored then plants can be returned to the wild **[1]** ;

b Any six from:

- quota is a limit on how much of the resource can be used ;
- logging companies allowed only to, take a certain quantity of trees / log a certain area ;
- therefore, enough trees remain to be able to maintain their populations ;
- some old trees kept in place to provide habitats for different species ;
- fishing vessels allowed only to take a certain amount of fish of particular species ;
- enough fish remain to be able to breed and maintain the population ;
- alternative valid point;

[Max. 6]

(Note: answers must be related to quotas, not other aspects of conserving these resources.)

Chapter 20

Questions

1 They reproduce quickly. They are able to synthesise complex molecules.

2 ethanol

3 carbon dioxide

4 It breaks down the pectin that holds cell walls together. This makes it easier for the cells to separate from one another, so the juice is more easily squeezed out.

5 enzymes, generally protease, lipase and amylase

6 The enzymes would be denatured in hot water.

7 Natural variation in the bacteria meant that some of them had enzymes (and other proteins) that were able to keep their shape and function at higher temperatures. These individual bacteria were able to survive in warmer water than others. They reproduced, passing on their alleles to their offspring. This continued over many generations, until whole populations of bacteria had enzymes able to function at higher temperatures.

8 Most people stop making the enzyme lactase in their digestive system when they are adults. They are therefore unable to digest lactose and may feel ill if they eat foods containing it. Lactose-free milk, and products made from it, are safe for them to eat.

9 Any living organisms in the fermenter must be destroyed before the microorganism that is to be grown in the fermenter is added. Otherwise, contaminating microorganisms could compete with the required one, reducing its growth. Even more importantly, they could produce substances that are not wanted, or are possibly even toxic, that could get into the required product and contaminate it.

10 If you want the microorganism to respire anaerobically – for example, if using yeast to make ethanol.

11 a It is a drug that is taken to kill pathogenic bacteria, without harming human cells.

b Carbohydrates will be used by the microorganism in respiration, to release energy for its growth. Amino acids will be used by the microorganism to make proteins, again needed for growth, but also to produce the enzymes that the microorganism uses to make the required product.

c Rotating paddles would break up the hyphae or get tangled up in them.

12 There are numerous ways in which this table could be completed. One possible way is shown here.

Type of genetic modification	One example	Comments
modifying bacteria to produce human proteins	GM bacteria synthesise human insulin.	This provides large quantities of insulin that can be used by people with type 1 diabetes.
modifying crop plants to confer resistance to herbicides	GM soya is resistant to glyphosate.	Farmers can kill weeds with glyphosate without harming the soya plants.
modifying crop plants to confer resistance to pests	GM cotton is resistant to attack by cotton boll weevils.	Farmers do not need to spray insecticide on the crop to kill insect pests.
modifying crop plants to improve nutritional qualities	Golden Rice contains large amounts of carotene.	Carotene is converted to vitamin A in the body, so children eating this rice will not suffer from vitamin A deficiency.

13 a to cut DNA, leaving sticky ends

b to join two DNA molecules together

Chapter 20 continued

14 Restriction enzymes cut DNA to leave a length of unpaired bases on one of the strands, called sticky ends. If the same restriction enzyme is used, then the same lengths of unpaired bases are left. This means that the sticky ends of each piece of cut DNA are complementary to one another and will bond together when they are mixed with each other. It is therefore possible to insert DNA into a cut plasmid.

Exam-style questions

1 C ; **[1]**

2 D ; **[1]**

3 B ; **[1]**

4 B ; **[1]**

5 C ; **[1]**

6 **a** **i** anaerobic **[1]** ; respiration **[1]** ;

ii carbon dioxide ; **[1]**

iii ethanol ; **[1]**

b **i** ethanol made from plant material **[1]** ; mixed with petrol (gasoline) **[1]** ;

ii waste plant material / sugarcane, is used to produce sugar **[1]** ; yeast uses the sugar in anaerobic respiration to produce ethanol **[1]** ;

7 **a** named protein (e.g. insulin, human growth hormone, other correct) **[1]** ; gene for making this protein inserted into bacteria **[1]** ; bacteria use the instructions on the gene to make the protein **[1]** ;

b Any one from: bacteria reproduce quickly so a lot of protein can be made or protein will always be of the same quality / product is predictable; (or an alternative valid point). **[1]** ;

c Any two from:

- selective breeding can be done by farmers, but GM requires laboratory ;
- selective breeding does not require a gene to be identified but GM does ;
- selective breeding does not involve the insertion of genes from another organism, but GM does ;
- selective breeding takes place over many generations, but GM is done in one generation ;
- alternative valid points ; **[Max. 2]**

8 **a** lactose dissolves in water **[1]** ; decreases the water potential in the lumen of the gut **[1]** ; water moves out of the cells lining the gut down its water potential gradient **[1]** ; by osmosis **[1]** ;

b Any three from:

- absorbed into capillaries in villi ;
- transported to heart via, hepatic portal vein / hepatic vein / vena cava ;
- transported to lungs in pulmonary artery ;
- diffuses across wall of capillary and wall of alveolus ; **[Max. 3]**

c Any six from:

- maintain pH of 6.5 ;
- using buffers / using a pH probe and adding acid or alkali ;
- maintain temperature of 35 °C ;
- using cold or hot water flowing through water jacket ;
- harvest after 48 hours ;
- provide nutrients / carbon source and nitrogen source ;
- provide oxygen for respiration ;
- stir to mix nutrients with bacteria ; **[Max. 6]**

Chapter 20 continued

9 a Any four from:

- both increase throughout the period ;
- herbicide-resistant soya starts at 8%, pest-resistant maize 2% in 1996 ;
- herbicide-resistant soya reaches peak use around 2011 and then levels off, but pest-resistant maize reaches peak at about 2012 ;
- by 2019 about 94% of soya was herbicide resistant, but only 83% of maize was pest resistant ;
- increase in use of herbicide-resistant soya was more rapid in early years than increase in use of pest-resistant maize ; **[Max. 4]**

b (farmer) obtains higher yields **[1]** ; without having to pay for pesticides **[1]** ; fewer pesticides mean less harm to non-pest insects **[1]** ;

c Any four from:

Advantages:

- can spray crop with, herbicide / glyphosate, without harming the soya plants ;
- kills weeds and reduces competition with the crop plants ;
- higher yields / saves time ;

Disadvantages:

- GM seeds more expensive to buy than ordinary seeds ;
- some consumers may not want to buy food containing GM soya so may be difficult to sell the crop ; **[Max. 4]**