Unit 1: Life and environmental sciences

Topic 1 Building blocks

Chapter 1.1: States of matter

Lesson 1.1a The particle model

1a solid

1b gas

1c liquid

2 In a gas the particles are far apart and move in all directions, whereas in a solid they are closer together and cannot change their position.

3 X is a solid; Y is a gas; Z is a liquid.

4 They are all solid spheres of the same size but there are no forces of interaction between them that vary with distance between the spheres.

5 Particles in a gas have different energies; when a gas cools down and condenses the particles become closer together and bonds form between some of the particles.

Lesson 1.1b Density

1 air; it is a gas

2 gold

3 In a solid particles are closer together than in liquids or gases.

4 Students' own annotated diagrams, based on Figure 1.1.6 (Gas) in the Student Book. In a gas the particles are very far apart, so the density is small.

5a density = mass ÷ volume; = 5400 kg ÷ 2 m^3 = 2700 kg/m^3

5b mass = volume × density; therefore 2 × 7700 = 15 400 kg

5c Steel has a greater mass than aluminium of the same volume; therefore a plane made from aluminium needs less energy to fly.

6 Volume of the room = 5 m × 4 m × 3 m = 60 m^3.
Mass = density × volume = 1.3 kg/m^3 × 60 m^3 = 78 kg

7 Cork has a density of 200 kg/m^3, water has a density of 1000 kg/m^3 and iron has a density of 8000 kg/m^3. Cork is less dense than water and therefore floats; iron is more dense than water and therefore sinks.

Lesson 1.1c Required practical: To investigate the densities of regular and irregular solid objects and liquids

1 The balance would also record the mass of the cylinder.

2 Measure the mass of the empty cylinder and then the cylinder plus the liquid, then subtract the first reading from the second reading to get the mass of the liquid alone.

3 density = mass / volume; density of coconut oil = 18.5 g / 20 cm^3 = 0.93 g/cm^3 or 0.93 kg/m^3; density of acetone = 19.6 g / 25 cm^3 = 0.78 g/cm^3 or 0.78 kg/m^3; density of sea water = 51.3 g / 50 cm^3 = 1.03 g/cm^3 or 1.03 kg/m^3.

4 = 2 cm × 2 cm × 3 cm = 12 cm^3

5 density = mass / volume; density of the cork = 3 g / 12 cm^3 = 0.25 g/cm^3 or 0.3 g/cm^3 to two significant figures

6 density of the oak is 17 g / 24 cm^3 = 0.7 g/cm^3; density of the tin is 364 g / 50 cm^3 = 7.3 g/cm^3

7 The answers for the Vernier callipers should only be to two significant figures, the same number as the component with the least number of significant figures.

8 Dangle the necklace in the water and collect the overflowed water into a container.

9 mass of the necklace and volume of overflowed water

10 density of gold = 19.29 g/cm^3; density of the necklace = mass of necklace/volume of water.

If the necklace is gold, the result should be 19.29 g/cm^3.

11 Difficulty in accurately measuring the overflowed water, as the necklace has a small volume and water may be difficult to collect.

Lesson 1.1d Key concept: Particle theory

1 A solid has particles very close together in an ordered pattern. Particles vibrate to and fro but cannot change their positions, so the solid has a fixed shape and volume. A liquid has particles close together but not in a regular pattern. The particles slide past each other, so the liquid has a fixed volume but not a fixed shape.

2 The state of matter depends on the amount of internal energy. As the solids are heated there is increase in internal energy and vibration of particles, which need more room and expand in all directions.

3 Students' own temperature–time graphs, based on Figure 1.1.15 in the Student Book.

4 The material is cooling.

Lesson 1.1e Gas pressure

1 The gas molecules move faster and have more kinetic energy.

2 The temperature is the average level of energy of the molecules in a substance.

3 Pressure is equal to the force on the wall divided by the area over which the force acts. Therefore, increasing the force on the outside wall and decreasing the volume of the balloon increases the pressure inside.

4 When gas particles hit a wall of their container there is a force on the wall. This force is the pressure of the gas.

5 In a sealed container the mass of a gas is constant because there is the same number of particles independent of changes in temperature and pressure.

6 With increase in temperature the gas particles have more energy and move faster, hitting the walls more often and with greater force so that the pressure increases.

7 In a smaller box containing the same number of gas particles, there will be more collisions between particles and walls of the container, and therefore the pressure is higher.

Lesson 1.1f Heating and changes of state

1 Sublimation is the change in state from solid to gas, without going through the liquid state.

2 Mass is conserved when substances change state, so you would have 45 g of iodine gas.

3 Coconut oil has the stronger forces between its molecules because more energy is needed to melt it.

4 Heating water to 100 °C transfers energy to the particles so they can escape the forces of attraction and become a gas. Water stays at 100 °C until all the particles have broken free.

5 As thermal energy is supplied to the system, the energy of the particles that make it up increases, and therefore the particles move faster; the internal energy increases.

6 Steam has more internal energy compared to hot water.

Lesson 1.1g Specific heat capacity

1 The particles in a liquid gain kinetic and potential energy when heated and will move over and around each other more; the internal energy increases.

2 The particles of a gas will start moving faster when heated and will move further apart.

3 The mass of water in the saucepan would be more than the mass of water in the cup, and more energy is needed to heat a larger volume of water.

4 Hot milk will give out less energy when cooling than hot water, as the internal energy stored in the system during heating was less for the hot milk than for the hot water.

5 The specific heat capacity of a substance is the energy needed to raise the temperature of 1 kg of the substance by 1 °C. The specific heat capacity of water is 4200 J/kg °C, 100 g = 0.1 kg. Change in temperature is

30 °C. Therefore $\Delta E = m \times c \times \Delta\theta = 0.1 \times 4200 \times 30 = 12\,600$ J or 12.6 kJ.

6 Any answer related to heating, such as radiators or hot water bottles.

7a The specific heat capacity of copper is 380 J/kg °C. I kW is defined as 1 kJ per second. Change in temperature of the water is 10 °C. Therefore $\Delta E = m \times c \times \Delta\theta = 1$ kg $\times$ 4200 J/kg °C $\times$ 10 °C = 42 000 J or 42 kJ.
For the kettle $\Delta E = m \times c \times \Delta\theta = 0.5$ kg $\times$ 380 J/kg °C $\times$ 10 °C = 1900 J or 1.9 kJ.
A 2 kW electric heater supplies energy at 2 kJ per second, so the time taken would be (42 kJ + 1.9 kJ) / 2 = 22 seconds.

7b We have assumed that all the energy in the copper pan is transferred without loss to the water.

8 Copper saucepans have a lower specific heat capacity than metals such as aluminium, so less energy is needed to heat them to a specific temperature.

Lesson 1.1h Required practical: Investigating specific heat capacity

1 Measure the temperature with a thermometer.

2 Compare the temperature measurements before and after the brass is transferred.

3 Subtract the final water temperature from the temperature of the brass in the first beaker (at 100 °C).

4 Both the water and the brass would cool down to room temperature.

5 Thermal energy in the brass may be lost if the brass cools down during transfer; therefore all of the energy may not transfer to the water.

6 Thermal energy will be lost to the surrounding atmosphere as the brass and the water equilibrate to room temperature.

7 The experiment assumes that the thermal energy in the brass is transferred to the water without loss. It is important to transfer the brass as quickly as possible and monitor the temperature regularly as the energy in the brass is transferred to the water.

8 Otherwise some of the energy transfer will be to the air.

9 $\Delta E = m \times c \times \Delta\theta = 0.25$ kg $\times$ 4200 J/kg °C $\times$ (9 °C) = 9450 J

10 9450 J

11 The brass would have decreased by 100 °C – 26 °C = 74 °C.

12 $m_{water} \times c_{water} \times$ temperature $\text{increase}_{water} = m_{brass} \times c_{brass} \times$ temperature decrease_{brass}, therefore = $c_{brass} = m_{water} \times c_{water} \times$ temperature $\text{increase}_{water} / m_{brass} \times$ temperature decrease_{brass}
= 0.25 kg $\times$ 4200 J/kg °C $\times$ 9 °C/0.15 kg $\times$ 74 °C = 851 J/kg °C

13 The brass may have lost energy during transfer between beakers; therefore the temperature decrease may not be accurate.

Lesson 1.1i Changes of state and specific latent heat

1 The solid is changing to a liquid or the liquid is changing to a solid.

2 Thermal energy transferred by heating changes the state of water. Energy is need to increase the movement of the water molecules; increased movement breaks the bonds between the water molecules so that they are free to move in all directions. The liquid (water) becomes a gas (steam).

3 Energy is required to break the bonds between the water molecules when ice melts. During this phase latent heat is used to break the bonds. Increase in temperature will occur only when the change of state has completed.

4 More energy is need to separate the particles during transfer from liquid to vapour than from solid to liquid.

5 $E = m L = 0.1$ kg $\times$ 340 000 J/kg = 34 000 J

6a ice to water: $E = m L = 0.2$ kg $\times$ 340 000 J/kg = 68 000 J
water to steam: $E = m L = 0.2$ kg $\times$ 2 260 000 J/kg = 452 000 J
water at 0 °C to water at 100 °C: $\Delta E = m c \Delta\theta$ = 0.2 kg $\times$ 4200 J/kg °C $\times$ 100 °C = 84 000 J

Total energy = 68 000 J + 452 000 J + 84 000 J = 604 000 J = 604 kJ

6b Students' own temperature–time graphs, based on Figure 1.1.25 in the Student Book.

Lesson 1.1j Maths skills: Drawing and interpreting graphs

1 Time 0:00 to 16:00 minutes; 25 to 95 °C

2 Temperature (°C) and Time (min)

3 Students' own labelled graphs, based on Figure 1.1.27 in the Student Book.

4 Two slopes between 95 and 68 °C between 0 and 5 minutes and 68 to 25 °C between 11 and 16 minutes and a plateau at 68 °C between 5 and 11 minutes. The stearic acid is solidifying at 68 °C.

5 The wax changes between two states from solid to liquid at 44 °C.

6 The wax is melting. Energy is required to transition from solid to liquid, called the latent heat of fusion, during which the temperature of the wax does not change.

7 44 °C

8 The stearic acid is changing state from a liquid to a solid. It is cooled as a liquid to the freezing point (end of the plateau) and then solidifies.

9 The stearic acid is solidifying, during which the temperature does not change because of the latent heat of fusion.

10 68.1 °C

11 The internal energy of stearic acid is decreasing as the temperature decreases. Particles become very close together in an ordered pattern and can vibrate but not change their position.

Lesson 1.1k Meaning of purity

1 Salt, milk and some cooking oils are pure in the everyday sense of the word, as they are natural substances with nothing added to them. Tea is an infusion of tea leaves and water mixed with milk. None of these substances is pure in the chemical sense.

2a any picture of a single atom element, such as gold

2b any picture of a mixture of two elements

2c any picture of a pure compound

3 Dry residue is 280 mg/l. 1 g in 100 ml is a 1% solution, 1 g in 1 l is a 0.1% solution, so 280 mg/l is a 0.03% solution.

4 Answers may include: benefits – no harmful substances or additives; risk: many different unknown substances may not have been tested.

5 Sam made the purest sample as the melting point did not change after the third crystallisation.

6 Akira had the purer sample as the boiling point was nearest that of the standard.

End of chapter questions

1 from left to right: gas, solid, liquid [1 Mark]

2 Gas – particles spaced far apart, move fast in all directions. Solid – particles close together in an ordered pattern, fixed shape. Liquid – particles close together but not in a regular pattern, not a fixed shape. [2 Marks]

3 Substance G is a liquid. [1 Mark]

4 c They have the same amount of energy. [1 Mark]

5 latent heat [1 Mark]

6 $\Delta E = m \times c \times \Delta\theta$ = 2 kg × 4200 J/kg °C × 10 °C = 84 000 J. [2 Marks]

7 Density = mass/volume. The unit is kg/m^3. [1 Mark]

8 a its colour [1 Mark]

9 Density = 0.1 kg / 0.000 025 m^3 = 4000 kg/m^3. The density of water is = 1000 kg/m^3, therefore it will sink. [2 Marks]

10 water to steam: $E = m L$ = 0.15 kg × 2 260 000 J/kg = 339 000 J [2 Marks]

11 The water molecules in the ice lose energy as the temperature decreases to the point at which the water starts to freeze. [3 Marks]

12 The molecules of a gas collide with each other as well as with the walls of their container. When they hit a wall there is a force on the wall. Pressure is equal to the force on the wall divided by the area over which the force acts. The total force exerted by all the molecules

inside the container that strike a unit area of the wall is the gas pressure. [2 Marks]

13 Materials with a high specific heat capacity release heat more slowly than materials with a lower specific heat capacity, so heating up the room for longer. [2 Marks]

14 $\Delta E = m \times c \times \Delta\theta$ = 0.1 kg × 4200 J/kg °C × 40 °C = 16 800 J [2 Marks]

15 liquid to ice: $E = m L$ = 0.045 kg × 340 000 J/kg = 15 300 J [2 Marks]

16 The amount of energy needed to break apart particles to form a gas is higher than that needed to change a solid to a liquid. [2 Marks]

17 The higher the temperature the faster the particles move and the more kinetic energy they have. The temperature of a gas is related to the average kinetic energy of the molecules. The molecules collide more frequently with each other and the sides of the container, thereby increasing the pressure. [2 Marks]

18 The internal energy is the energy stored by particles in a system and is dependent on mass, type of material and energy input. An increase in the internal energy can change the state of the particles. Changing the temperature of a material is change in the external energy input. [2 Marks]

19 $\Delta E = m \times c \times \Delta\theta$ = 2 kg × c × 10 °C = 8880 J, therefore c = 8880 / 20 = 444 J [2 Marks]

20 steam to water: $E = m L$ = 0.05 kg × 2 260 000 J/kg = 113 000 J. [2 Marks]

21 By increasing the volume the molecules collide less frequently with each other and the sides of the container, thereby decreasing the pressure. [2 Marks]

[Total 37 Marks]

Chapter 1.2 Atomic structure

Lesson 1.2a Scientific models of the atom

1 Dalton's theory was that atoms were solid particles that could not be broken up into smaller particles.

2 The discovery of the electron meant that the atom could be divided into smaller sub-atomic particles.

3 Thomson proposed that atoms were made up of negative electrons embedded in a ball of positive charge. Rutherford suggested that the atom had a positively charged nucleus, but much of the atom was empty. The nucleus was too massive for the number of positively charged protons it contained. The discovery of the neutron changed the theories, as it has mass but no charge.

4 Discoveries of new particles that changed the theories for the structure of the atom.

5 If the atom was a ball of positive and negative charges, then all the alpha particles in Geiger and Marsden's scattering experiment should have passed through the foil. The fact that some alpha particles were repelled meant that there were distinct areas of positive and negative charges. Most particles went straight through the metal foil because its matter was mostly empty space, but a few had 'struck' some small but strong obstacle: the nuclei of the atoms.

6 Accept something like 'Independent evidence from several different teams help a scientific theory to be accepted.'

Lesson 1.2b The size of atoms

1 mostly empty space, in which electrons move around the nucleus

2 10^{-11} m

3 The size of a skin cell is 40 000 nm, or 4×10^4 nm.

4 A skin cell is 4×10^{-5} m and a methane molecule is 5×10^{-10} m, so the order of magnitude difference is 4.

5 0.36 nm

6 There are 2 chlorine and 3 sodium atoms. The diameter of the molecule is 1.4 nm. Therefore the diameter of each chlorine atom = 1.4 – (3 × 0.36) / 2 = 0.16 nm, and the radius is 0.08 nm.

Lesson 1.2c Maths skills: Standard form and making estimates

1 1×10^{9}

2 100 000 000

3 1×10^{-18}

4 0.000 000 001

5a $18 \times 10^{12} = 1.8 \times 10^{13}$

5b $24 \times 10^{7} = 2.4 \times 10^{8}$

5c 3×10^{6}

6 Distance is 1.5×10^{11} m = 1.5×10^{8} km

7 Mass of 1 atom = 3.3×10^{-22} g; therefore the mass of 3.0×10^{26} atoms is 9.9×10^{4} g.

Lesson 1.2d Sub-atomic particles

1 negative

2 Each proton has a positive charge. An atom always has the same number of protons and electrons.

3 20

4 A fluorine atom has 9 protons, 9 electrons and 10 neutrons.

5 A chlorine atom has 17 electrons, 17 protons and 18 neutrons.

6 The nucleus contains the protons and neutrons that make up almost all the mass. Protons and neutrons are bound together by the powerful nuclear force. The larger radius contains the electron cloud.

7

	Atomic no.	Mass no.	No. of protons	No. of electrons	No. of neutrons
C	6	12	6	6	6
F	9	19	9	9	10
Na	11	23	11	11	12
Al	**13**	**27**	**13**	**13**	**14**

8 15 protons, 15 electrons and 16 neutrons

Lesson 1.2e Maths skills: Sizes of particles and orders of magnitude

1 1 basketball = 25 cm.
1 km = 1000 m = 100 000 cm.
Therefore number of basketballs = 100 000/25 = 4000 or 4×10^{3}.

2 Carbon nanotube = 2×10^{-9} m = 2×10^{-6} mm, therefore 1 mm would fit 1 / 2×10^{-6} = 500 000 = 5×10^{5} nanotubes.

3 2.5×10^{-11} m ÷ 1.75×10^{-15} m = 1.43×10^{4} times larger

4 0.000000000001 m = 1×10^{-12} m in standard form.

5 0.5 m ÷ 500 000 m = 5×10^{-1} m ÷ 5×10^{5} m = 10^{-6}

6 1.2×10^{-5} m ÷ 1.2×10^{-4} m = 10^{-1}

Lesson 1.2f Isotopes

1 Isotopes are different forms of the same element with the same atomic number but different mass numbers.

2 Both isotopes have 3 protons. One has 3 neutrons and the other has 4 neutrons.

3 $^{14}_{7}$N has 7 protons and 7 neutrons; $^{15}_{7}$N has 7 protons and 8 neutrons

4 Uranium: $^{235}_{92}$U has 92 protons and 143 neutrons; $^{238}_{92}$U has 92 protons and 146 neutrons.

5 All the isotopes have 1 electron and 1 proton each. $^{1}_{1}$H has 0 neutrons and a mass number of 1, $^{2}_{1}$H has 1 neutron and a mass number of 2, and $^{2}_{1}$H has 2 neutrons and a mass number of 3.

6a The atomic number, the number of protons and the number of electrons in any element are all the same.

6b The atomic number and the number of protons are the same. The number of neutrons can be the same, more or less than the number of protons.

Lesson 1.2g Electrons in atoms

1 empty space

2 The number of protons with a positive charge is equal to the number of electrons with a negative charge.

3 15

4 2, 8, 5

5 Argon electronic structure is 2, 8, 8.

6 Students' own diagrams, based on Figure 1.2.12 in the Student Book, but magnesium electronic structure is 2, 8, 2 and argon electronic structure is 2, 8, 8.

End of chapter questions

1 Students' own diagrams, based on Figure 1.2.7 in the Student Book [1 Mark]

2 c 7 [1 Mark]

3a negative [1 Mark]

3b no charge [1 Mark]

3c positive [1 Mark]

4 2 electrons in the inner shell and 8 in the outer shell [1 Mark]

5 1×10^{6} [1 Mark]

6 1×10^{-10} m [1 Mark]

7 Dalton described atoms as tiny spheres that could not be broken up. [1 Mark]

8 The atomic number is the number of protons.

9 23 is the mass number (protons and neutrons) and 11 is the atomic number (protons). [1 Mark]

10 Isotopes are different forms of the same element with the same atomic number but different mass numbers. [1 Mark]

11 1×10^{10} [1 Mark]

12 Thomson's discovery of the electron. [1 Mark]

13 There are 15 electrons. [1 Mark]

14 $^{28}_{14}$Si contains 14 neutrons and $^{30}_{14}$Si contains 16 neutrons. [1 Mark]

15a $32 \times 10^{9} = 3.2 \times 10^{10}$ [1 Mark]

15b $15 \times 10^{6} = 1.5 \times 10^{7}$ [1 Mark]

16 If the atom was a ball of positive and negative charges, then all the alpha particles in Geiger and Marsden's scattering experiment should have passed through the foil. The fact that some alpha particles were repelled meant that there were distinct areas of positive and negative charges. Most particles went straight through the metal foil because its matter was mostly empty space, but a few had 'struck' some small but strong obstacle: the nuclei of the atoms. [4 Marks]

17 Accept something like 'Independent evidence from several different teams help a scientific theory to be accepted. Scientists propose a hypothesis, test it, publish papers in scientific journals, and have their work checked and replicated by other scientists.' [3 Marks]

18 15 electrons, 15 protons and 16 neutrons [2 Marks]

[Total: 28 Marks]

Chapter 1.3 Cells in animals and plants

Lesson 1.3a Electron microscopy

1 200 nm or 0.2 mm

2 ×1500

3 Light microscope has ×1500 magnification; TEM has ×1 000 000 magnification; order of magnitude difference is 3.

4 TEM: cells; SEM: small organisms and cells

5 Leaf pore measured as 19.5 mm, which is 19 500 000 nm; magnification = ×1500; therefore actual length is 19 500 000 / 1500 = 13 000 nm, which is 1.3×10^{4} nm in standard form.

6 The image is 6 cm, which is 60 000 μm; the actual cell is 1.2×10^{2} μm, which is 1200 μm. Therefore the magnification is 60 000 / 1200 = ×50.

7 Anything like 'To investigate the structure of in cells, large molecules, biopsy samples, metals, and crystals. Industrially, the electron microscope is often used for quality control and failure analysis.'

Lesson 1.3b Cell structures

1 nucleus, chromosomes, cell membrane, cytoplasm, mitochondria, ribosomes

2 vacuole, chloroplasts, cell wall

3 The nucleus contains the cell's hereditary information, DNA and RNA, and controls the cell's growth and reproduction; the cell membrane surrounds the cytoplasm of a cell and controls the passage of substances in and out.

4 cellulose in the cell wall

5 Prokaryotic cells are much smaller than eukaryotic cells, around 0.1–5.0 μm in diameter and do not have a nucleus containing DNA.

6 Their DNA is not enclosed in a nucleus. It is found as a single molecule in a loop. They may also have one or more small additional rings of DNA called plasmids.

7 Animal cell: image is 3.5 cm, cell is 60 μm. Magnification = 35 000 / 60 = ×583.
Plant cell: image is 1.5 cm, cell is 30 μm. Magnification = 15 000 / 30 = ×500.

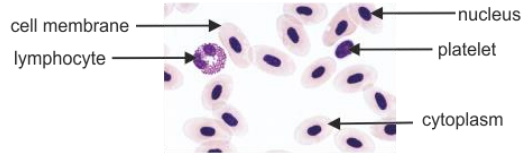
8 Mitochondrion measured as 35 mm; magnification = ×25 120; therefore actual length is 35 / 25 120 = 1.4 μm = 1.4×10^3 nm.
Chloroplast measured as 30 mm; magnification = ×6300; therefore actual length is 30 / 6300 = 5 μm = 5×10^3 nm.

Lesson 1.3c Required practical: observing cells under a light microscope

1 List should include: microscope, slide, cheek cell, mouth swab, coverslip, mounting liquid.

2 Cells survive longer in saline solution as it has the same concentration as them, whereas in water the cells would burst (see topic 1.3f).

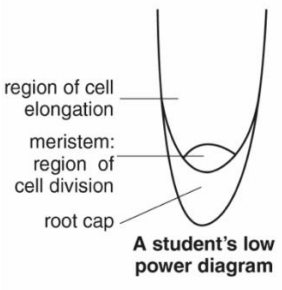
3a



3b Frog red blood cells contain a nucleus.

4 to locate the cells

5



6 The magnification is ×200 and the scale bar is 10 mm (10 000 μm) wide, which means that the scale bar corresponds to 50 μm.

7 Size of real object = size of image ÷ magnification, so 10 000 μm ÷ 200 = 50 μm.

Lesson 1.3d Maths skills: size and number

1 Count the number of cells and multiply by the cell size.

2 Quicker than working out accurate measurements.

3 65 × 2.8 μm = 182 μm

4 35 μm ÷ 2.8 = 12.5 μm

5 Smallest to largest: lymphocyte, neutrophil, macrophage, megakaryocyte

6 $= 1.5 \times 10^{-4} \div 7.5 \times 10^{-6} = 2 \times 10^{-3}$

Lesson 1.3e Diffusion into and out of cells

1 Because it happens due to the random motion of particles and doesn't require extra energy.

2 Because there is no longer a concentration gradient, which is needed for diffusion.

3 It will increase the speed of diffusion.

4 more area in which the liquid can cross

5 Small glucose molecules pass between the components of the thin cell membranes.
Students' own diagrams, based on Figure 1.3.15 in the Student Book.

6 Diffusion would eventually stop once the particles were evenly spread out and there was no longer a concentration gradient. However, diffusion does not cease in living organisms because cells are continually using up their supplies of dissolved substances such as oxygen and glucose for cellular activities, and waste products such as carbon dioxide are constantly being removed.

Lesson 1.3f Osmosis

1 Water passes through the tiny holes in the membrane.

2 Diffusion is the net movement of particles from a higher concentration to a lower concentration, down a concentration gradient.

Osmosis is specifically the diffusion of water molecules from a dilute solution to a more concentrated solution across a partially permeable membrane.

3 Water enters the cell by osmosis and fills the vacuole. This pushes against the cell wall, making the cell swollen, or turgid. If water moves out the cell by osmosis, the vacuole shrinks and the cell becomes floppy, or flaccid. If too much water leaves the cell, the cytoplasm shrinks and moves away from the cell wall.

4 In animal cells, when the external solution is more dilute than that inside the cell, water enters the cell; the cell swells and may burst. When the external solution is more concentrated than that inside the cell, water moves out of the cell by osmosis; the cell shrinks and shrivels.

5 Plant cells have an inelastic (rigid) cell wall and so do not burst when a large amount of water enters the cell – unlike animal cells, which have an elastic cell wall.

6 Water molecules and sugar molecules in a solution move around randomly. When a sugar molecule hits a membrane, it bounces away. When a water molecule hits a membrane, it can pass through a hole to the other side. If, there are more water molecules on the left of the cell, more water molecules can pass through the membrane to the right-hand side than can pass in the opposite direction. The water molecules move both ways, but the *net movement* is from left to right.

Lesson 1.3g Required practical: Investigating osmosis

1 higher concentration inside the cell

2 lower concentration inside the cell

3 from the inside of the cell to outside

4 Hypothesis: The onion cells in salt solution will shrink and lose mass, and the onion cells in water will swell and gain mass.

5 potato pieces, beakers, water, salt solutions of various concentrations, paper towel, weighing scales

6 independent variable: concentration of the salt solution, time; dependent variable: change in mass

7 so that none of the recorded mass was the mass of water on the potato pieces

8

Concentration of NaCl solution (g dm^3)	Mean starting mass (g)	Mean final mass (g)	Mean change in mass (g)	Mean % change in mass
0.00	15.9	17.0	1.1	6.9
9	19.2	20.1	0.9	4.7
18	24.1	23.3	–0.8	3.3
26	20.7	19.2	–1.5	7.2
35	24.1	22.0	–2.1	8.7
44	14.9	13.5	–1.4	9.4

9a Add all values together and divide by 5.

9b to reduce any variability in the results

10 Because the potato cylinders may not be all the same starting weight. A percentage better reflects the change.

11a Students' own graphs based on mean percentage change data from question 8. The final result is anomalous because the mass is lower than the starting mass.

11b They should be removed.

11c Below 18 g/dm^3 NaCl solution the final mass increases; at 18 g/dm^3 and above NaCl solution the final mass decreases.

12 Their hypothesis was correct.

13 Below 18 g/dm^3 NaCl solution the final mass increases as water moves into the cell; above 18 g/dm^3 NaCl solution the final mass decreases as water moves out of the cell.

14 Use a greater number of cylinders. Do the experiment more than once. Any suitable response for health and safety.

15 Students' own investigations; accept any suitable response showing good experimental plan, graph and evaluation.

Lesson 1.3h Maths skills: The spread of scientific data

1 9.6 mmol/dm^3

2 0.3 mmol/dm^3

3 26.7 cm^3 oxygen/g

4 26.7 cm^3/g $\pm$ 0.7 cm^3/g

Lesson 1.3i Active transport

1 Plants absorb minerals by using active transport to move the minerals into their root hair cells, from the soil water around the roots, against the concentration gradient.

2 Diffusion and osmosis are passive processes that involve molecules moving down a concentration gradient and do not require extra energy; active transport requires energy to move molecules against the concentration gradient.

3 The cells require specific substances to function correctly and cannot get them through the passive processes diffusion and osmosis. Therefore they need to use energy in active transport to move the substances in against the concentration gradient.

4 Special carrier molecules in the membrane, called transport proteins, attach to ions outside the cell and then rotate and release the ions on the inside of the cell. Different carriers transport different ions.

5 Passive transport (diffusion and osmosis) requires no energy. Diffusion is the net movement of particles from a higher concentration to a lower concentration, down a concentration gradient. Osmosis is the diffusion of water molecules from a dilute solution to a more concentrated solution across a partially permeable membrane. In active transport, substances move against a concentration gradient. This process requires energy to take place.

Lesson 1.3j Mitosis and the cell cycle

1 46 (23 pairs)

2 From the longest chromosome to the shortest chromosome, followed by the sex chromosomes.

3 For growth and development, and to replace worn out and damaged body cells in injured tissues.

4 46 chromosomes (the same as the parent); two daughter cells are produced

5 They are made up of two identical molecules of DNA joined in the middle.

6 The onion cells in the micrograph are all at different stages of the cell cycle. Some of them have not yet got to the stage in which the DNA condenses and becomes visible as chromosomes.

7 Mitosis is needed to produce more cells of the same type so that the organism can grow or replace damaged tissues. Therefore, all the cells need to be genetically identical to their parent cells.

8 Accept any answer involving rapid growth, repair or replacement of cells.

Lesson 1.3k Meiosis

1 4

2 23

3 1

4 2

5 Genetic material is exchanged between chromosomes when they line up before the first division. Then which chromosome from which parent cell goes into which gamete is completely random.

6 All 46 chromosomes come from the same parent. There is no exchange of genetic material.

Lesson 1.3l Cell differentiation

1 Motor nerve cells need to transmit electrical impulses from one part of the body to another to stimulate the muscles to move the skeleton. They are adapted to this by being long, having extensions that communicate with other cells,

branches that connect with muscle cells and gaps in a fatty covering called the myelin sheath, which allow the impulses to travel faster.

2 Red blood cells are small and flexible so that they can squeeze through small blood capillaries. Being without a nucleus leaves room to pack in more haemoglobin so that they can carry more oxygen around the body.

3 to differentiate into any type of cell

4 to replace dying cells and repair damaged tissues

5 embryonic stem cells

6 Some people might think that we should not use stem cells from developing embryos to create artificial blood, as all life is sacred, including embryonic life.

End of chapter questions

1a A: (i) cell membrane
B: (iii) cytoplasm [2 Marks]

1b C: (iii) DNA [1 Mark]

2 It has a cell wall, chloroplasts and a large vacuole. [2 Marks]

3 sperm cell, root hair cell, hen's egg, nerve cell [2 Marks]

4 8 [1 Mark]

5 Mitosis: the chromosomes are moving apart to the cell poles before the cell divides into two cells. [2 Marks]

6 Pollen grains are produced during meiosis. In this process, the chromosomes divide and double and then divide into 4 daughter cells with half the number of chromosomes. [2 Marks]

7 Mitochondrion: Respiration
Ribosome: Protein synthesis [2 Marks]

8 Meiosis: Sperm production
Mitosis: Growth of a human embryo [2 Marks]

9 Through osmosis, water moves into the amoeba from its surroundings. Without the vacuole to remove the water, the amoeba would swell and burst. [4 Marks]

10 Mitosis produces identical cells for growth and repair of tissue, which are essential in plants and animals. [2 Marks]

11 Water moves from outside the cell by osmosis, and moves into the vacuole, which pushes on the cell wall, making the cell swollen, or turgid. [3 Marks]

12 74 beats per minute $\times$ 10 minutes $\times$ 70 cm^3 per beat = 51 800 cm^3 = 51.8 litres [3 Marks]

13 23 chromosomes come from one parent and 23 chromosomes from the other parent. Genetic material is exchanged between these chromosomes when they line up before the first division in meiosis. Four gametes are produced, and which chromosome from which parent goes into which gamete is completely random. [6 Marks]

14 Carbon dioxide for photosynthesis: diffusion, a type of passive transport down a concentration gradient, which requires no energy. Essential minerals: active transport, involving movement against a concentration gradient, which needs energy from respiration. Water: osmosis, passive movement of water from a high concentration to a low concentration across a permeable membrane, which requires no energy. [6 Marks]

[Total: 40 Marks]

Chapter 1.4 Waves

Lesson 1.4a Key concept: Transferring energy and information by waves

1 Light travels at a slower speed than sound.

2 Students' own diagrams, based on Figure 1.4.10 in the Student Book.

3 more energy would be transferred

4 traffic lights, lights on ships and planes

5 any suitable example, such as radio waves for communication

6 any suitable examples, such as food absorbing microwaves, ultraviolet light being reflected by snow, X-rays being reflected in X-ray telescopes, gamma rays being absorbed by lead

Lesson 1.4b Transverse and longitudinal waves

1 Objects floating on water bob vertically up and down as waves pass along the water.

2 Alex is wrong because in a transverse wave, the vibrations are at right angles to the direction the wave is moving, so the water doesn't move along with the wave. The objects might be moving over the water because the wave has transferred energy to their kinetic energy store – but they are not being carried along with the water.

3 Pushing and pulling vigorously increases the frequency of the waves along the slinky compared with pushing and pulling gently.

4 There is no air in space (it is a vacuum) and sound waves cannot travel through a vacuum.

5a This is not an accurate method. It would be hard to judge exactly when the wave reached the other end of the swimming pool. There are also likely to be many other waves in the pool which would make the measurement confusing. Also there is only one measurement.

5b You could repeat the experiment several times and take an average. You could also video the wave from above and use software to play the video back in slow motion and to calculate the time it took the wave to travel the 25 m.

6 speed = distance / time = 20 / 10 = 2 m/s

Lesson 1.4c Measuring wave speed

1 The time between claps is 23 s ÷ 50 = 0.46 s.
Speed = distance / time
= 100 m / 0.46 s = 217 m/s

2 any suitable answer, such as: the wind might be affecting the speed the sound travels; problems with clapping at the same time that you hear an echo; measuring errors in the distance and the time

3 Distance = speed × time = 1500 × 0.1
= 150 m.
The sound has travelled to the fish and back again so the distance between the boat and the fish = 150 / 2 = 75 m.

4a Distance = 220 × 2 = 440 m

4b Time = distance / speed = 440 / 330 = 1.3 s

5 15 cm

6 The sound waves travel through the iron railing and also through the air. Sound travels faster through the iron railing so Ann hears the sound wave that has passed along the iron railing first and then she hears the sound wave that has passed through the air.

Lesson 1.4d A wave equation

1a Wavelength (λ) is the distance from a point on one wave to the equivalent point on the adjacent wave. Wavelength is measured in metres (m).

1b Frequency (f) is the number of complete waves passing a point in one second. It is measured in hertz (Hz).

1c Amplitude is the maximum displacement of a point on a wave away from its undisturbed position.

2 As the amplitude increase the amount of energy transferred increases.

3 2

4a $f = 1 / T = 1 / 0.1$ s = 10 Hz

4b $f = 1 / T = 1 / 0.25$ s = 4 Hz

5 $v = f\lambda$ = 2 Hz × 0.1 m = 0.2 m/s

6 $\lambda = v / f$, so when the frequency doubles, the wavelength halves.

7 $\lambda = v / f$ = 300 000 000 m/s ÷ 104 000 Hz = 2885 m

Lesson 1.4e Required practical: Measuring the properties of waves

1 It shakes the wooden rod, which produces the ripples in the tank.

2a metres (m)

2b Hertz (Hz)

3 You could use a transparent ruler taped onto the bottom of the tank of water. The shadow of the ruler can be used to measure the distance between the ripples on the viewing screen.

4 to reduce variability and get a more accurate measurement

5 She can divide the number of waves she counts by 10.

6 They could measure the time taken for a single ripple to move from one end of the tank to the other and divide the distance by the time.

7 They could count the number of waves passing a point during a fixed amount of time and multiply that by the wavelength.

8 to increase accuracy and see if both methods produce the same answer

9 The mean of the answers should be calculated, after disregarding any anomalies.

10 Divide the length of the bar, 1 m, by the mean time interval, in seconds, to get speed in m/s.

11 1 m ÷ 0.22 ms = 4.545 m/ms = 4545 m/s. The experimental value compares poorly.

Lesson 1.4f Electromagnetic waves

1a The amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.

1b The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.

2 sound waves

3 In transverse waves, the vibrations are at right angles to the direction of travel. In longitudinal waves, the vibrations are along the same direction as the direction of travel.

4 They don't need a material to carry them; they can travel in a vacuum.

5 They are all transverse waves and they all travel at the same speed in a vacuum.

6 gamma rays

7 $f = v / \lambda = 3 \times 10^8$ m/s ÷ 3.5×10^{-7} m = 8.6×10^{14} Hz

8 $f = v / \lambda = 3 \times 10^8$ m/s ÷ 0.2 m = 1 500 000 000 Hz = 1.5×10^9 Hz

Lesson 1.4g Uses of electromagnetic waves

1 Similarities: they are both electromagnetic wave.
Differences: Gamma rays tend to have a higher frequency than X-rays (although there is some overlap); gamma rays come from the nucleus of an atom whereas X-rays are produced by the electrons.

2 Usually radiotherapy needs X-rays that transfer a higher energy than the X-rays used for imaging. This means that X-rays used for radiotherapy will tend to have shorter wavelengths.

3 Longer wavelengths of infrared can pass through the glass but the shorter wavelengths of ultraviolet are absorbed.

4 to show where heat is being lost from the house, in order to improve the insulation

5 Microwaves don't pass through the walls of houses very effectively.

6 Radio telescope sources are objects in space, such as stars, nebulas and galaxies. Energy is transferred as radio waves. The absorber is the antenna and the radio receiver.

7 The antenna intercepts radio waves and converts them to currents that are applied to the receiver. The receiver extracts the desired information from the radio wave.

Lesson 1.4h Required practical: Investigating infrared absorption and radiation

1 The experiment shows how quickly different surfaces can absorb infrared radiation.

2 The stopper connected to the blackened metal plate should drop first. This is because black surfaces absorb infrared more effectively than shiny surfaces.

3 The thickness of the plates should be the same, the mass of the stoppers and the amount of wax used to stick them should be the same, the heater needs to give the same heat transfer in both directions and the plates need to be placed the same distance either side of the heater.

4 This ensures that the temperature of each surface is the same.

5 To make it a fair test and ensure that the effect of the area on the infrared radiation is kept the same.

6 The infrared detector needs to be placed the same distance from each of the sides of the container.

7 a comparative bar graph

8 The blackened bulb will absorb the infrared effectively and so the thermometer can measure the amount of infrared being produced.

9 The temperature is proportional to the amount of infrared radiation.

10a It needs to be white or shiny (so that it doesn't absorb much infrared radiation).

10b They need to be matt black (so they absorb lots of infrared radiation).

11a It needs to be shiny (so that it doesn't emit much infrared radiation).

11b They need to be matt black (so they emit lots of infrared radiation).

Lesson 1.4i Reflection and refraction of electromagnetic waves (HT only)

1 Paper is a rough surface and light rays from one direction are scattered in all directions.

2 Mirrors are smooth shiny surfaces that reflect back the light not absorbed by the clothes.

3 Students' own ray diagrams, based on Figure 1.4.25 in the Student Book, with appropriate labelling but representing water, e.g. in a beaker. Only the ray from water to air needs to be shown.

4 A line at right angles to the surface of the glass.

5 Students' own wavefront diagrams, based on Figure 1.4.26 with appropriate labelling

6 The speed of the wave has increased.

Lesson 1.4j Maths skills: Using and rearranging equations

1a $T = 1 / 100\ \text{Hz} = 0.01\ \text{s}$

1b $T = 1 / 1000\ \text{Hz} = 0.001\ \text{s}$

1c $T = 1 / 15\,000\ \text{Hz} = 0.000\,067\ \text{s} = 6.7 \times 10^{-5}\ \text{s}$

2a $f = 1 / T = 1 / 5 = 0.2\ \text{Hz}$

2b $f = 1 / T = 1 / 10 = 0.1\ \text{Hz}$

2c $f = 1 / T = 1 / 150 = 0.0067\ \text{Hz}$
$= 6.7 \times 10^{-3}\ \text{Hz}$

3a $v = f\lambda = 100\ \text{Hz} \times 2\ \text{m} = 200\ \text{m/s}$

3b $v = f\lambda = 100\ \text{Hz} \times 2\ \text{cm} = 200\ \text{cm/s} = 2\ \text{m/s}$

3c $v = f\lambda = 100\ \text{Hz} \times 2\ \text{mm} = 200\ \text{mm/s} = 0.2\ \text{m/s}$

4 $f = v / \lambda$

5a $f = v / \lambda = 25\ \text{m/s} \div 0.5\ \text{m} = 50\ \text{Hz}$

5b $f = v / \lambda = 250\ \text{m/s} \div 0.05\ \text{m} = 5000\ \text{Hz}$

5c $f = v / \lambda = 2500\ \text{m/s} \div 0.005\ \text{m} = 500\,000\ \text{Hz} = 500\ \text{kHz}$

6a $\lambda = v / f$

6b $\lambda = v / f = 330\ \text{m/s} \div 500\ \text{Hz} = 0.66\ \text{m}$

7 Speed of red light = distance / time
$= 3.0\ \text{m} / 1.0 \times 10^{-8}\ \text{s} = 3.0 \times 10^{8}\ \text{m/s}$
$f = v / \lambda = 3.0 \times 10^{8}\ \text{m/s} \div 6.5 \times 10^{-7}\ \text{m}$
$= 4.6\ \text{Hz}$

8 Frequency of sound wave in air $= v / \lambda$
$= 330\ \text{m/s} \div 0.25\ \text{m} = 1320\ \text{Hz}$
In titanium, $\lambda = v / f = 6100\ \text{m/s} \div 1320\ \text{Hz}$
$= 4.6\ \text{m}$ (to 2 significant figures)

End of chapter questions

1 A sound wave [1 Mark]

2 The wavelength of a wave is the distance between one peak and an adjacent peak or between one trough and an adjacent trough. [2 Marks]

3 C hertz [1 Mark]

4 $T = 1/ f = 1 / 4 = 0.25\ \text{s}$ [1 Mark]

5 ultra high frequency waves [1 Mark]

6 This is called diffuse reflection. The reflected light is scattered in all directions. [2 Marks]

7a B and D [2 Marks]

7b B and C [2 Marks]

7c A [2 Marks]

8 A infrared; B X-rays [1 Mark]

9 microwaves and infrared radiation [1 Mark]

10a any one of: cooking, communication [1 Mark]

10b any one of: killing cancer cells, sterilising medical equipment, in radioactive tracers [1 Mark]

11a gamma rays [1 Mark]

11b long-wave radio waves [1 Mark]

12 $v = f\lambda = 2\ \text{Hz} \times 0.08\ \text{m} = 0.16\ \text{m/s}$ [2 Marks]

13a transverse waves [1 Mark]

13b entire range of wavelengths or frequencies of *electromagnetic* radiation, including radio waves, infrared, visible light, ultraviolet, X-rays and gamma rays [1 Mark]

14 The ray of light is refracted towards the normal as it enters the transparent block. [2 Marks]

15 Students' own wavefront diagrams, based on Figure 1.4.26a in the Student Book [3 Marks]

16 As the ship is moving along, the sea bed gradually becomes deeper, then stays at a constant depth and then gradually gets shallower. The anomalous result could be from a fish swimming underneath the ship but close to the surface. [6 Marks]

17 Time between the pulses = 0.0600 – 0.0500 = 0.0100 ms
Distance travelled in this time = speed × time = 4000 m/s × 0.0100 × 10^{-3} s = 0.0400 m [6 Marks]

[Total: 40 Marks]

Topic 2 Transport over larger distances

Chapter 2.1 Systems in the human body

Lesson 2.1a Cellular respiration

1 any suitable answers, including for cell division, active transport, maintaining the body temperature, moving, growing, sending nerve impulses

2 to release the energy from food

3 Birds and mammals make use of the waste thermal energy to keep warm.

4 in cells, in the cytoplasm and the mitochondria

5 They produce carbon dioxide and water.

6 Respiring cells release thermal energy.

Lesson 2.1b Comparing aerobic and anaerobic respiration

1 respiration without oxygen

2 When there is not enough oxygen for aerobic respiration.

3 glucose → lactic acid + energy

4 It is less efficient than aerobic respiration and so glucose molecules are not completely broken down (oxidised), which means that much less energy is released.

5 The amount of energy produced is enough to keep cells running for a while longer when oxygen is temporarily unavailable.

6 The sprinter needs to take in extra oxygen to remove lactic acid in the muscles; the amount of extra oxygen needed is called the oxygen debt.

Lesson 2.1c Key concept: The need for transport systems in multicellular organisms

1 cell, tissue, organ, system, human body

2 any two cells and any two tissues in the circulatory system

3 The larger the cell the more chemical activity takes place.

4 any one from: respiration, enzyme reactions, protein synthesis

5 They both get larger, but surface area increases more than volume.

6 The surface area : volume ratio decreases.

7 It makes it more difficult to absorb enough of the substances the cell needs to stay alive and to get rid of the waste products made.

8 So that nutrients and waste products can be transported to and from the cell to meet the organisms needs, so that it can survive.

Lesson 2.1d Maths skills: Surface area : volume ratio

1 14 cm^2

2a 90 cm^2

2b 400 mm^2

3a 450 m^3

3b 24 cm^3

4 The volume is measured by measuring the volume of water that overflows.

5 sides of 1 cm: surface area 6 cm^2; volume 1 cm^3, surface area : volume ratio 6 : 1

sides of 2 cm: surface area 24 cm^2; volume 8 cm^3, surface area : volume ratio 3 : 1
sides of 3 cm: surface area 54 cm^2; volume 27 cm^3, surface area : volume ratio 2 : 1
sides of 4 cm: surface area 96 cm^2; volume 64 cm^3, surface area : volume ratio 3 : 2
sides of 6 cm: surface area 216 cm^2; volume 216 cm^3, surface area : volume ratio 1 : 1
sides of 8 cm: surface area 384 cm^2; volume 512 cm^3, surface area : volume ratio 3 : 4

6a B will have problems keeping cool, because it has a small surface area : volume ratio.

6b C will have problems keeping warm, because it has a large surface area : volume ratio.

7 Accept any sensible answer.

Lesson 2.1e Exchange surfaces

1 They have a large surface area to maximise rate of exchange, a thin membrane to provide a short diffusion path and a method of transporting substances to and from the exchange surface.

2 In smaller organisms, nutrients, oxygen and waste substances can quickly diffuse in and out. Transport systems are needed in larger organisms so that cells deep inside the organism:

- get the oxygen and nutrients they need for chemical reactions
- are able to get rid of the waste products of chemical reactions and any excess heat generated.

3 Blood transports the gases to and from the surface of each alveolus through the capillaries that cover it. Air entering the alveoli has a greater oxygen concentration than the deoxygenated blood flowing through the lungs. This causes a steep concentration gradient, from high to low concentration, and allows efficient diffusion of oxygen in the air to the blood. Deoxygenated blood has a greater carbon dioxide concentration than air in the alveoli, so carbon dioxide diffuses from the blood into the alveoli before being breathed out.

4 Breathing is taking oxygen into the lungs and expelling carbon dioxide out of the lungs. Respiration is the chemical reaction between glucose and oxygen to release energy. Carbon dioxide and water are waste products of respiration.

5 Alveoli are spherical, and there are millions in each lung, which provides a vast total surface area. The exchange surface at the alveolus wall is very thin (one cell thick), so diffusion distance for gases is very short. Each alveolus is closely surrounded by a network of capillaries to ensure a good blood supply.

6 Oxygen is constantly taken away in the blood, and carbon dioxide is constantly brought to the lungs to be removed. So gas exchange happens at a steep concentration gradient. Constant ventilation continually brings oxygen-rich air into the lungs and expels carbon dioxide, which also help maintain steep concentration gradients of gases. The alveoli surfaces are moist. Gases dissolve to allow efficient diffusion across the exchange surface.

7 to allow efficient diffusion without the need for extra energy input

Lesson 2.1f The human heart

1 to pump blood around the body

2 76 bpm

3 The right atrium receives deoxygenated blood from the body, and the right ventricle pumps it to the lungs; the left atrium receives oxygenated blood from the lungs, and the left ventricle pumps it around the body.

4 Blood enters the heart at the atria. The ventricles relax whilst the atria contract and push blood into the ventricles. The valve between the atria and ventricles closes and the atria relax whilst the ventricles contract to push blood out of the heart towards the body.

5 The left atrium receives oxygenated blood from the lungs and contracts to push it through the open valve into the left ventricle. At the same time, the right atrium receives

deoxygenated blood from the rest of the body and contracts to push it through the open valve into the right ventricle. The valves between the atria and ventricles then close. The left ventricle contracts to send oxygenated blood through the open valve to the rest of the body. At the same time, the right ventricle contracts to send the deoxygenated blood through the open valve to the lungs. These valves then close.

6 The coronary artery supplies blood to the heart muscle, providing oxygen and glucose for respiration. If the coronary artery supplying the left ventricle becomes blocked the heart may be unable to function properly and pump blood effectively to the body.

Lesson 2.1g The human circulatory system

1 A circulatory system in which the blood flows in two circuits round the body.

2 the aorta and the pulmonary artery

3 Deoxygenated blood from the body is pumped from the right ventricle of the heart, through the pulmonary artery, into the capillary networks around each the alveoli in the lungs. Here, at the specialised surfaces of the alveoli, oxygen from the air inside the alveolus diffuses into the blood, and carbon dioxide from the blood diffuses into the air inside the alveolus.

4 Oxygenated blood is pumped from the left ventricle of the heart, through the aorta, to the body. The blood then enters arterioles supplying the organs and tissues and passes into networks of tiny capillaries, which lie very close to every body cell. Here, oxygen diffuses from the blood into the cells, and carbon dioxide diffuses from the cells into the blood, each down its concentration gradient. Next, the deoxygenated blood moves into venules, and then into veins, which carry it back to the right side of the heart.

5 Arteries have thick, impermeable, elastic walls with small lumen, to carry blood under high pressure. Capillaries have one-cell-thick, permeable walls, with a huge total surface area, for efficient exchange with body cells. Veins have thinner, impermeable walls with a large lumen, providing less flow resistance, for carrying blood under low pressure and have valves to prevent backflow.

6 so that substances don't diffuse into and out of them

Lesson 2.1h Blood cells

1 left: platelet; middle: red blood cell; right: white blood cell. Diagram is not to scale.

2a Red blood cells carry oxygen from the lungs to body cells.

2b White blood cells help to protect the body against infection.

3 Plasma transports substances around the body, including hormones, nutrients and waste substances such as urea and carbon dioxide. It is made up of 90% water and 10% solutes.

4 Red blood cells are tiny, allowing them to pass through the narrow capillaries; they have a biconcave disc shape, giving them a large surface area : volume ratio, which increases the efficiency of diffusion of oxygen into and out of the cell, and reduces the diffusion distance to the centre of the cell; they contain haemoglobin, which binds to oxygen to transport it from the lungs to the body tissues; they have no nucleus, increasing the space available for haemoglobin.
White blood cells are adapted to fight infections. Some types produce antibodies, which help destroy invaders. Others can change shape to engulf bacteria. Platelets are adapted to help seal wounds and prevent excessive bleeding. They are tiny cell fragments without a nucleus that become 'sticky' when activated at a wound site, and help form a clot.

5 Haemoglobin binds with oxygen at high concentration to form oxyhaemoglobin. The bonds between the haemoglobin and oxygen are weak, and oxyhaemoglobin dissociates to

haemoglobin and oxygen in low oxygen concentrations.

6 Red cells are biconcave in shape. This gives the cell a bigger surface area : volume ratio, which increases the rate of diffusion of oxygen into and out of the cell.

7 Because of the sickle shape of the red blood cells they cannot carry oxygen around the body as efficiently. This means that their cells would lack of oxygen for respiration and the person would feel tired and breathless when exercising.

Lesson 2.1i The human digestive system

1 to absorb nutrients that can be used for respiration or to make new large molecules that cells need as energy reserves or for growth and repair

2 the process of moving small, soluble food molecules into the blood from the small intestine

3 the breakdown of insoluble proteins to soluble amino acids

4 glycerol and fatty acids

5 Digestive enzymes do not work inside cells because they would destroy the cell components.

6 It is about 7 m long, so there is time for absorption of soluble molecules as food travels along it. It has a very thin, permeable membrane for easy diffusion. The cells lining the small intestine have many small projections called villi, each with even tinier projections called microvilli, increasing the surface area for absorption. Blood capillaries transport molecules away, maintaining the concentration gradient for diffusion. Lacteals carry fatty acids away through the lymphatic system, which eventually returns them to the blood.

7 because most fats do not mix easily with water in the blood and would clump together, making them difficult to break down

Lesson 2.1j Required practical: Food tests

1a pestle and mortar

1b dropping pipette or glass rod

1c measuring cylinder or calibrated dropping pipette

2 to ensure maximum surface area is exposed to the test solutions/molecules released from cells

3 the Biuret test

4 care with grinding food; safety googles for Biuret test; heat with a water bath (not a Bunsen burner); do not eat food in laboratory; check for allergies

5 to make her results more valid

6 to make a fair test; to see whether the procedure itself has an effect on the results

7 any suitable table to fit data, including units

8a A: Biuret reagent did not change from blue to purple-pink

8b A and C: Benedict's reagent changed from blue to brick-red

8c A: Sudan III reagent formed a red layer combining with the lipid

Lesson 2.1k The human nervous system

1 to detect the surroundings and coordinate body functions and behaviour

2 central nervous system and peripheral nervous system

3 neurone

4 stimulus → receptor → coordinator → effector → response
Receptors detect stimuli (changes in the environment) and sensory neurones relay nerve impulses from these receptors to the central nervous system (CNS). The CNS processes the information and coordinates how the body should respond. Motor neurones relay impulses from the CNS to the effector (e.g. a gland or a muscle).

5 the myelin sheath

6 Neurones are long, extended cells with branches that enable them to communicate with other neurones; the myelin sheath of neurones enables the electrical impulses to

jump from gap to gap and speed up transmission throughout the nervous system.

Lesson 2.1l Reflex actions

1 a rapid, automatic response to a stimulus

2 They help to prevent organisms from being hurt and aid survival.

3 reflex arc

4 A sensory neurone transmits electrical impulses from the receptor to the CNS; a relay neurone in the spinal cord transmits the impulses from the sensory neurone to the motor neurone; a motor neurone sends the impulses from the CNS to the effector.

5 a synapse

6 Chemical transmitter molecules are released from one neurone and diffuse across the synapse to another neurone, where they bind to receptors.

7 Stimulus → receptors → sensory neurone → relay neurone in CNS → motor neurone → effector → response

Lesson 2.1m Required practical: Investigating reaction time

1 Students' own risk assessments for this experiment. A model Risk assessment proforma could include the following:
Name of hazard, e.g. chemical, material, biological material or activity that could be a hazard; type of hazard; risks associated with hazard; steps taken to minimise risks; (optional) emergency procedure. The hazards listed in the risk assessment could include the following, where appropriate:

- Handling/carrying/catching metre rulers.
- Caffeine.

The caffeine is likely to be in coffee, so care must be taken with hot drinks and it should not be drunk in the laboratory, where there is risk of contamination with chemicals or microorganisms. Caffeine may have adverse effects on some students and intake must be limited for all students.

2 The results for Test 5 for Experiment 1 are anomalous.

3 average before coffee = 1160 ÷ 10 = 116 mm; after the anomalous result is removed = 112 mm

4 average after coffee = 930 ÷ 10 = 93 mm

5 If taking in caffeine through a drink of coffee, the intake of caffeine needs to be standardised, i.e. the caffeine must be of the same concentration and the volume drunk must be the same for each student. A further improved way of administering the caffeine would be for a set mass (e.g. 1–3 mg) per kilogram of student body mass. If the caffeine intake were not standardised, the results obtained from different students could not be compared.

6 a histogram, as the values show ranges; students' own histograms, using the data from the table on page 147 of the Student Book

7 The median and mode reaction time categories are both 301–325.

8 The computer method is more accurate and measures the reaction time directly, with no outside influences such as gravity and subconscious clues from the student dropping the ruler.

Lesson 2.1n The endocrine system

1 It works alongside the nervous system to coordinate and control the body's activities.

2 target organs such as the thyroid gland, adrenal gland, ovaries and testes

3 It regulates the secretion of other endocrine glands.

4 growth hormone

5 receptors detect changes in the environment

6 The nervous system is rapid and precise, whereas the endocrine system is slower but acts for longer. The nervous system uses electrical and chemical messages, whereas the endocrine system uses only chemical messages (hormones). The electrical impulse in the nervous system is carried by neurones to a specific location, whereas hormones in

the endocrine system are carried in the blood all over the body.

Lesson 2.1o Negative feedback

1 adrenaline

2 The blood flow is diverted away from the skin and digestive system towards the brain and muscles.

3 any from: increase in metabolism, persistent tiredness, weight loss, heart palpitations, anxiety

4 stimulates the basal metabolic rate

5 thyroid-stimulating hormone (TSH)

6 A negative-feedback system is one in which changes are detected and reversed to bring them back into a normal range.

7 With a heating system/thermostat, the heating system is switched off by the effect, i.e. the temperature having been reached; the switching on and off of thyroxine secretion is not regulated by the action of the thyroxine on the thyroid gland itself; the thyroxine acts on the pituitary gland, which responds by producing another hormone (TSH) that acts on the thyroid gland.

End of chapter questions

1 large surface area, a method of transporting substances to and from the surface [2 Marks]

2 arteries, veins, capillaries [2 Marks]

3a to pump blood around the body [1 Mark]

3b to supply oxygen and glucose for respiration to the heart muscle [1 Mark]

4 by plasma in the blood [1 Mark]

5 Fats are digested by lipases into fatty acids and glycerol. Proteases break down proteins into amino acids. Carbohydrates are digested by carbohydrases into simple sugars. [2 Marks]

6 glucose + oxygen → carbon dioxide + water (+ energy) [1 Mark]

7 Any from: It is very long and has a thin, permeable membrane for easy diffusion. It has villi and microvilli, which hugely increase the surface area for absorption. Blood capillaries and lacteals transport substances away, maintaining the concentration gradient. [2 Marks]

8a The nervous system uses nerve electrical impulses (electrical and chemical messages), whereas the endocrine system uses hormones (chemical messages). [1 Mark]

8b The nervous system is rapid and precise whereas the endocrine system is slower but acts for longer. [1 Mark]

9a the pituitary gland [1 Mark]

9b Because it secretes adrenaline. [1 Mark]

10a deoxygenated [1 Mark]

10b oxygenated [1 Mark]

10c oxygenated [1 Mark]

11 blood pumped = 74 bpm × 10 min × 70 cm^3 blood = 51 800 cm^3 blood = 51.8 litres blood [1 Mark]

12a

	Aerobic respiration	Anaerobic respiration
Where does it occur?	in all cells	In muscle cells
When does it occur?	at all times	during vigorous exercise
What are the by-products?	carbon dioxide and water	lactic acid
How much energy is produced?	a great deal	much less – only 5% of that from aerobic respiration
Oxygen needed?	Yes	No
Oxygen debt produced?	No	yes

[3 Marks]

12b Lactic acid from anaerobic respiration builds up in the muscles and stops them from contracting efficiently. [1 Mark]

12c The muscles run out of oxygen and respire anaerobically. Glucose is converted to lactic acid. The oxygen debt is the amount of extra oxygen the body needs to react with the accumulated lactic acid and remove it from the cells. The oxygen oxidises the lactic acid to carbon dioxide and water. [2 Marks]

13 Its small size means that nutrients can diffuse in and waste materials can diffuse out directly. [3 Marks]

14 Increased thyroxine levels increase metabolism, so the body temperature would rise. [2 Marks]

15 Absorption of nutrients from food occurs at a slower rate because of the reduced surface area of the small intestine. [4 Marks]

16 Four correct answers from: mother's finger on baby's palm detected by receptors (in baby's skin); message/nerve impulse sent to spinal cord; along sensory neurone; impulse travels through relay neurone; to motor neurone; impulse causes contraction of muscles in hand; so that baby grasps finger [4 Marks]

[Total: 39 Marks]

Chapter 2.2 Plants and photosynthesis

Lesson 2.2a Meristems

1 at the tips of roots and shoots

2 Some of the daughter cells differentiate into different types of cells depending on where they are in the plant.

3 They are clones of cells taken from one plant.

4 nutrients, agar, plant hormones

5 to provide new daughter cells that can specialise into different cell types

6 Multicellular organisms need to be made up of a variety of different cell types with specialised functions to make the organism work as a whole.

Lesson 2.2b Plant structures

1 Glucose made in the leaves has to be transported to every cell in the plant for respiration.

2 The leaves make food for the plant by photosynthesis from water and carbon dioxide.

3 Leaves have tiny pores called stomata that allow gases to enter and leave. Most leaves are very thin, so gas molecules can diffuse into the cells once they have entered the stomata.

4 During the day, carbon dioxide diffuses into the leaves through the stomata for photosynthesis, and a relatively small amount of oxygen diffuses in for respiration; at night, there is no inward diffusion of carbon dioxide, as there is no photosynthesis, and so the inward diffusion of oxygen for respiration is greater.

5 Water and mineral ions are taken into plants through the roots and are transported throughout the plant in the xylem in the process of transpiration (see topic 2.2c).

6 Magnesium is needed to make chlorophyll for photosynthesis, so the leaves would look yellow instead of green.

Lesson 2.2c Transpiration

1 the movement of water through the plant, in through the roots out through the leaves

2 in through the root hairs, up the stem in the xylem tissue to the leaves, where some exits the plant through evaporation

3 They have a large surface area over which water and dissolved minerals can be absorbed, a thin outer membrane for rapid absorption, a thin cell wall to reduce the distance that materials must move across, and a large permanent vacuole to absorb as much water as possible, and they are close to the xylem vessels in the root.

4 Each root hair cell has a long, thin extension that reaches out between the soil particles. Active transport is needed to move the mineral ions into the root hairs. Root hair cells contain many mitochondria to provide the energy for this.

5 They are hollow tubes made up of many long dead cells lying end to end. They have thick walls containing lignin, which makes them strong and waterproof.

6 The cells need to be strong, waterproof and hollow to fulfil the function of carrying water and minerals around the plant.

Lesson 2.2d Looking at stomata

1 Transpiration occurs because water vapour is able to diffuse through the stomata in the leaves, causing more water to be drawn up through the plant.

2 for photosynthesis, to carry dissolved materials around the plant, for support, for evaporation to cool the leaves

3 Plants vary in how much water they need to lose through their stomata. For example, in desert areas plants have fewer stomata because they need to conserve water.

4 It has rolled leaves with a thick waxy cuticle and stomata sunk into pits. Interlocking hairs hold water vapour.

5 The stomata close, and the leaves droop down to reduce the surface area for water loss by evaporation.

Lesson 2.2e Rate of transpiration

1 to compare the rate of transpiration in photosynthesising plants in the light and in non-photosynthesising plants in the dark

2 mass before and after the investigation to calculate percentage weight loss; surface area of each leaf to calculate percentage water loss for a given area

3 The leaves are detached from the plant and so transpiration through the plant, from roots to leaves, is not being measured directly.

4 Set up two shoots in potometers. Put one in front of a fan (wind) and one in an area with no wind for a set period of time and measure the distance moved by the air bubble.

5 The shoots are detached from the plant and only the rate at which water is taken up is being measured; the rate of transpiration through the plant, from roots to leaves, is not being measured directly.

6 so that they could calculate the mean of the three trials to give a more accurate result

7 temperature, light intensity

8

	Rate of uptake of water (mm/min)			
Light intensity (arbitrary units)	Trial 1	Trial 2	Trial 3	Mean
10	5.0	7.0	5.0	5.7
20	5.0	7.0	5.0	5.7
30	12.0	12.0	11.0	11.7
40	24.0	23.0	26.0	24.3
50	32.0	33.0	32.0	32.3

Students' own graphs, plotted with the means in the table above. Transpiration increases with light intensity from 30 units of light onward.

9 No photosynthesis was taking place.

10 The concentration of water vapour builds up outside the leaves and transpiration stops.

Lesson 2.2f Chlorophyll and other plant pigments

1 because the water the solvent moves through the paper, which stays still

2 because the spot will dissolve in the water

3 There is no yellow spot at the correct position for pigment 2 in the leaf mixture.

4 Pigments 1, 2 and 3 and chlorophylls A and B have just one spot each. For the leaf mixture, there are four distinct, indicating that it is a mixture of pigments 1 and 3 and chlorophylls A and B.

5 $R_f = 56 / 70 = 0.8$

6 Distance = 90 mm $\times$ 0.68 = 61 mm

Lesson 2.2g Required practical: Paper chromatography

1 The ink contains dyes which would move up the paper with the solvent. This would interfere with the other spots.

2 to increase the concentration loaded

3 just dipped into the solvent below the start line

4 until the solvent front reaches near to the top of the paper

5 The solvent front has not moved as far as in Alex's or Sam's experiment. She started the

experiment later than the others or drew her start line in a different place from the others.

6a a result that does not fit with the trend

6b any sensible explanation as to why Alex's value for pigment B should be so much higher than those of Sam and Jo

6c Repeat the experiment and re-measure the distance, comparing it to Sam and Alex's results.

7

Chromatogram	R_f value			
	A	B	C	D
Sam's	0.96	0.64	0.28	0.17
Alex's	0.97	-	0.26	0.18
Jo's	0.97	0.65	0.28	0.17

8 pigment A: carotene; pigment B: xanthophyll; pigment C: chlorophyll A; pigment D: chlorophyll B

Lesson 2.2h Photosynthesis

1 carbon dioxide and water

2 light

3 glucose and oxygen

4 a chemical reaction that absorbs heat

5 Plants respire all the time, day and night.

6 So that their cells can still respire at night when the plants are not making glucose from photosynthesis.

7 for energy and to make starch, cellulose, fats and oils, and amino acids

8 The products of photosynthesis (oxygen and glucose) are the reactants for respiration, and vice versa. The chemical reaction for photosynthesis is the reverse of that for respiration. Respiration takes place all the time but photosynthesis only takes place in the light.

Lesson 2.2i Factors affecting the rate of photosynthesis

1 They can produce food by photosynthesis more quickly when the light intensity is greater and the temperature is warmer.

2 In the rainforest, there is more water available but less light due to clouds. In the desert, there is less water and more light.

3 to increase ventilation and the flow of air through the greenhouse if the conditions inside the greenhouse become too hot on sunny days

4 to increase the temperature on cooler days and nights; also, as the fuel burns it produces carbon dioxide, which can be used in photosynthesis during the day

5 carbon dioxide or temperature

6 As temperature increases the rate of photosynthesis increases and then declines. There is an optimum temperature range for photosynthesis to occur.

7 The rate of photosynthesis depends on light intensity, carbon dioxide and water and nutrient levels and temperature. These are monitored to maximise food production.

8 Limiting factors can be optimised. Heating and artificial lighting are provided. Crops are protected from bad weather.

Lesson 2.2j Maths skills: Looking at tables and graphs

1a 6 arbitrary units

1b The rate plateaued.

2a at 9 and 14 arbitrary units

2b Rate of photosynthesis increases with increase in light intensity up to 9 arbitrary units, then the rate plateaus, even though light intensity is still increasing.

3 The graph is clearer because it is easier to see the trends in the data.

4 because a line of best fit should be a smooth curve, and so might not pass through every data point

5 The rate of photosynthesis increases linearly (A) with increasing concentration of carbon dioxide up to 11% carbon dioxide concentration (B). At higher carbon dioxide concentrations, between 15 and 25 there is no increase in the rate of photosynthesis and the line of best fit plateaus (C).

Lesson 2.2k Required practical: How does light affect the rate of photosynthesis?

1 when the lamp is closest to the pondweed, at a distance of 10 cm

2 Increasing light intensity will speed up the rate of photosynthesis.

3 As the rate of photosynthesis increases, more oxygen will be produced.

4 temperature of water; volume of water; size of the pondweed; angle of lamp

5 As the light intensity increases more bubbles of oxygen will be produced because the rate of photosynthesis will increase.

6 The results in test 1 are all higher than in the subsequent tests, except for the first reading at 10 cm, which was much lower.

7 In the first test, the apparatus may not have been set up correctly or consistently; the number of bubbles may have been mis-counted; the water may have been warmer; the lamp may have been closer (distance not accurately measured).

8 If they identified that the problem with the Test 1 results was experimental error, they should consider not using these results. It would be best to repeat the investigation a third time to make sure.

9 to identify anomalous results and experimental error; to increase reliability

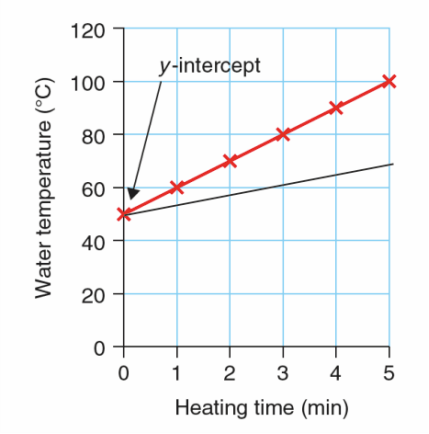
10 as a line graph, because photosynthesis is a continuous process

11 Students' own graphs, using the Test 2 and 3 data from the table on page 179 of the Student Book

Lesson 2.2l Maths skills: Calculating rate of change from a line graph

1 50 °C

2 Students' own graphs, similar to that below



3 (100 – 80)°C / (5 – 3) min = 20 °C / 2 min = 10 °C per min

4 because the water reaches its boiling point at 100 °C

5a (30 – 10) kg / (8 – 0) months
= 20 kg / 8 months = 2.5 kg per month

5b (50 – 20) kg / (20 – 0) months
= 30 kg / 20 months = 1.5 kg per month

6 (43 – 0) kg / (24 – 0) months
= 43 kg / 24 months = 1.8 kg per month

Lesson 2.2m Translocation

1 Carbohydrates and proteins are large and insoluble, whereas amino acids and sucrose are small and soluble.

2 the movement of sugars around plants, from where they are produced to where they are needed

3 Students' own diagrams, showing any of the following: glucose being stored as starch, converted to cellulose, used to make fruits/seeds, converted into lipids and proteins, used for growth and repair.

4 Phloem cells have end walls with sieve plates, cytoplasm but no nucleus and a companion cell with a nucleus next to them.

5 Phloem tissue is living. The cells have thin walls and perforated ends. Xylem tissue is made up of dead cells, with strengthened walls and no ends, forming hollow tubes.

6 Phloem are living cells with no nucleus; the companion cells have a nucleus to control the phloem cells' activities and lots of

mitochondria to supply the energy needed for translocation to take place in the phloem cells.

7 to allow the movement of substances through the phloem

Lesson 2.2n Plant diseases

1 microorganisms that cause diseases that can be passed from one organism to another

2 viruses or fungi

3 a distinctive 'mosaic' pattern of discolouration on the leaves, curled leaves and stunted growth

4 a fungus

5 by direct contact between the leaves or stem of different plants, and also by human handling of infected and healthy plants

6 by spores of the fungus which are produced in the black spots and released in wet, humid conditions

7 any three from: removing infected plants or dropped leaves to avoid spores spreading; not planting roses too close together, so that air can flow freely around them; avoiding getting the leaves wet when watering, as wet leaves encourage the growth of the fungus; spraying with a fungicide to prevent or treat infection, especially in advance of warm, wet weather.

End of chapter questions

1a to produce glucose for energy [1 Mark]

1b chloroplasts [1 Mark]

1c starch [1 Mark]

1d phloem [1 Mark]

1e glucose and oxygen [2 Marks]

2a Students' own diagrams, with blue, yellow, green and purple spots [2 Marks]

2b R_f = distance moved by the compound / distance moved by the solvent [2 Marks]

3 any two from: in respiration to produce energy; to make cellulose, which strengthens the cell wall; to make fats and oils for storage; to make amino acids for protein synthesis [2 Marks]

4 It is expensive to manipulate the conditions by providing heat, light and carbon dioxide. [1 Mark]

5 any of: use fungicide, remove and burn infected leaves, grow a resistant plant variety, grow plants in sunny non-damp locations with good air circulation, use well-draining soil, water plants in the morning to prevent plants being damp overnight, prune plants regularly and before the growing season to remove infected stems [4 Marks]

6a Water uptake is highest between 5 and 6 pm. [1 Mark]

6b As the transpiration rate increases and more water is lost from the leaves, the rate at which the roots take water in starts to increase to replace the water lost.
or
As the transpiration rate decreases and less water is lost from the leaves, the rate at which the roots take water in starts to decrease. [2 Marks]

7 Control conditions to maximise the rate of photosynthesis: add paraffin heater to increase temperature and produce carbon dioxide; use a watering system to supply water, use blinds to control the amount of light; add moisture to the air with a humidifier. [4 Marks]

8 There is a decrease in mass in all the plants over a 12-h period due to loss of water by transpiration, but the *Begonia* loses less water than the *Coleus*. The *Begonia* has a slower transpiration rate than the *Coleus*, perhaps because it is better adapted to reduce water loss. [6 Marks]

9 $CO_2 + H_2O \rightarrow {}^{(light)} C_6H_{12}O_6 + O_2$ [2 Marks]

10 to cool the leaves through evaporation; to keep water moving throughout the plant where it is needed; to keep dissolved minerals entering the roots with more water [2 Marks]

11a temperature, carbon dioxide, water [2 Marks]

11b Students' own diagrams, with correctly labelled equipment and experimental set-up [2 Marks]

11c Light intensity = 1 / distance^2 = 1 / 10^2 = 0.01 [2 Marks]

[Total: 40 Marks]

Topic 3 Interactions with the environment

Chapter 3.1 Lifestyle and health

Lesson 3.1a Health and disease

1 physical, mental and social wellbeing

2 disease, diet, life situations and stress

3 any one communicable disease such as measles or HIV; any one non-communicable disease such as diabetes, cancer or cardiovascular disease

4 any examples of viruses, bacteria, fungi or protists, such as measles, salmonella, the protist that causes malaria, rose black spot

5 by direct contact, by water, through the air

6 High-fat or sugar-rich diets can cause high blood pressure, depression, heart disease and strokes, eating disorders and Type 2 diabetes. Low-calcium diets cause osteoporosis. Red meat and processed meat increase the risk of bowel cancer.

7 Various lifestyle factors can cause stress, which in turn can cause depression and eating disorders.

8 financial burden of healthcare costs on local, national and global economies.

Lesson 3.1b Risk factors for non-communicable diseases

1 genetics, diet, obesity and amount of exercise

2 reduce alcohol consumption, eat a healthier diet, lose weight, change drug habits, prevent viral infection

3 any sensible idea, such as people found it hard to stop their addiction to cigarettes and didn't want to believe the link between smoking and lung cancer; not everyone who smoked developed lung cancer; the tobacco companies were slow to accept the evidence

4 Cigarette consumption decreased after the 1970s. The death rate in men declined after the 1990s. The death rate in women plateaued after the 1990s. The effects of smoking occurred around 20 years after first smoking in men. Death rates may be linked to factors other than smoking in women.

5 Lung cancer mainly occurs in people who have been smoking for many years.

6 any sensible suggestion, such as the consumption of red meat, alcohol and sugary foods is higher because there is more money to spend on these items

Lesson 3.1c Treatments for cardiovascular disease

1 a build-up of fatty material inside the coronary artery, reducing blood flow; death of heart cells; heart attack

2 poor diet, smoking, genetic factors

3 drugs called statins and changes in diet to reduce cholesterol; insertion of a stent; bypass surgery

4 Artificial valves are mechanical devices that can replace faulty heart valves, to prevent the backflow of blood in the heart.

5 For a heart transplant or valve replacement, major surgery is required, whereas it isn't for pacemakers. For both heart transplants and artificial pacemakers, the body can reject the new heart or pacemaker, so anti-rejection drugs are needed following a heart transplant, and there is the chance that another new pacemaker will need to be fitted. By contrast, there is no rejection following artificial valve insertion, although red blood cells can be damaged and the patient will need anti-clotting drugs. A main drawback of heart transplant is that there is a shortage of donors, but the main advantage is that it offers a better quality of life.

6 Increase in consumption of a high fat diet. Statins stop the liver producing as much cholesterol.

Lesson 3.1d Maths skills: Analysing and interpreting data

1 (a) Average brithweight is related to cigarette consumption. (b) Whooping cough vaccination

92% from 2000 to 2004 but decreased to 84% in 2005.

2 (a) The maximum birthweight (3.5 g) was in babies of mothers who did not smoke during pregnancy. The more cigarettes consumed in pregnancy, the lower the birthweight. (b) Whooping cough decrease is linked to vaccination increase. The minimum vaccination rate in 2005 occurred at the same time as the maximum incidence of whooping cough.

3 There is no correlation between water intake and incidence of coronary heart disease. There is a negative correlation between vaccination uptake and incidence of flu cases. There is a positive correlation between amount of exercise and incidence of osteoarthritis.

4 If the proposed cause only sometimes results in the disease, the disease has many possible causes and there is a long delay between proposed cause and effect.

5 Students' own scatter graphs of the data in the table on page 201 of the Student Book

Lesson 3e Homeostasis

1 Enzymes and other cell functions work best at a particular temperature. The brain is very sensitive to temperature change.

2 any suitable answers, such as energy intake, heat loss

3 Homeostasis is the regulation of internal conditions in an organism.

4 to maintain the optimum conditions for enzymes to work and for efficient body functions

5 special receptor cells in the body detect changes levels of blood sugar, water and temperature

6 The nervous system communicates rapidly using electrical impulses carried by nerve cells to specific effectors in the body; the endocrine system coordinates slower but longer-lasting responses using hormones, carried around the body in the blood.

Lesson 3.1f Controlling blood glucose

1 insulin

2 It causes glucose in the blood to move into the body's cells.

3 The concentration of glucose in the blood increases after a meal.

4 60 minutes

5 4–7 mmol/dm^3

6 Insulin restores the blood glucose concentration to its normal level. A little insulin is produced as you first smell or chew food. As you eat food and it's digested, the blood glucose concentration rises, which causes a surge in insulin. The insulin concentration reaches a peak, then gradually falls.

Lesson 3.1g Diabetes

1 In Type 1 diabetes, the pancreas is unable to produce enough or any, insulin. Patients with Type 1 diabetes control it with insulin injections,

2 Without glucose, cells must use alternative energy sources. Fat and protein are used. The person will lose weight. If the condition is not controlled, kidney failure and death will result.

3 In Type 2 diabetes, the body's cells lose their sensitivity to insulin.

4 Type 2 diabetes can be managed by modification of diet, and a controlled exercise regime.

5 In the non-diabetic person the blood glucose concentration returns to normal after a meal. In the person with untreated Type 2 diabetes, blood glucose concentration increases after a meal and is not brought back to normal. In the treated diabetic person, the blood glucose concentrations follow the same pattern as those of the non-diabetic person but are always slightly higher.

6 There might be a genetic link, and also members of the same family are likely to eat similar foods and have similar levels of exercise.

7 There is a positive correlation between risk of diabetes and obesity in both men and women.

However, the effect is stronger in women. Women who are obese (93%) or overweight (40–50%) have an increased risk of diabetes compared with obese (42%) or overweight (12–25%) men.

Lesson 3.1h Human reproductive hormones

1 testosterone (men), oestrogen (women)

2 Secondary sex characteristics develop as our bodies produce these hormones at puberty, including breast development and pubic hair growth in girls and a deep voice and pubic hair growth in boys.

3 follicle stimulating hormone (FSH), luteinising hormone (LH), oestrogen and progesterone

4 oestrogen and progesterone

5 FSH and LH concentrations increase; oestrogen and progesterone levels fall. Ovulation occurs as a result.

6 negative feedback – oestrogen and progesterone; positive feedback – follicle stimulating hormone, luteinising hormone.

Lesson 3.1i Contraception

1 hormonal methods and barrier methods

2 middle of menstrual cycle, around 14 days, slight increase in body temperature, thinning of mucus secreted from the cervix

3 condom, diaphragm

4 to help with the effectiveness of other contraceptives, such as diaphragms (but not condoms)

5 They inhibit the release of the pituitary hormones and thicken the cervical mucus.

6 A contraceptive that is placed in the uterus and includes hormones, such as synthetic progesterone or have fine copper wire wrapped round them that is toxic to sperm.

7 any suitable ethical answer framed correctly as an argument

Lesson 3.1j Which contraceptive?

1 Use correctly following guidance and teaching; use computerised devices that monitor hormone changes.

2 IUDs and oral contraceptives

3 Oral contraceptives are absorbed by the digestive system and may be removed by vomiting or diarrhoea, whereas injections, implants and patches act directly via the bloodstream.

4 advantages: works immediately or can stay in place for 10 years (copper) or 3–5 years (hormonal); disadvantages: insertion may be uncomfortable or periods may be longer or more painful

5 contraceptive pill

6 Condom: can protect against transmitted infections, e.g. HIV; are widely available; may slip off and must withdraw after ejaculation and not spill semen; Diaphragm: put in just before sex; no health risks; needs to be left in for several hours after sex; some people sensitive to spermicide. Both are disposed of in landfill.

7 any suitable ethical answer framed correctly as an argument, including that it can be seen as interfering with human rights and reproductive freedom but may help the control of the world population and sustainability

Lesson 3.1k Treatments for infertility

1 They stimulate ovulation.

2 to look at the number and size of developing follicles

3 fertilisation of eggs outside the body

4 any two of: younger age, previous pregnancy, BMI within the range 19–30, low alcohol and caffeine intake, non-smoking

5 A single sperm is sometimes selected and injected into the egg using a microscopic needle.

6 from stimulation of the ovaries to implantation

7 For both, FSH and LH are given. For IVF only, eggs are fertilised outside the body.

Lesson 3.1l IVF evaluation

1 the National Institute for Health and Care Excellence (NICE) and the couple's local NHS

2 It prepares the couple for the chances of success and failure.

3 38%

4 three of: premature birth, stillbirth, low birthweight, infant death, multiple births

5 Students' own answers, based on either 'replacing the physical and emotional relationship involved in conceiving with laboratory technique' or 'treating a human embryo as a mass of cells to be used, selected and discarded'

6 as a technique to select a particular type of child

End of chapter questions

1a Insulin is produced in the pancreas. [2 Marks]

1b diabetes [1 Mark]

2 heart, coronary arteries [1 Mark]

3a a factor that increases the chance of having a disease [1 Mark]

3b any two of: diet, obesity, age, genetics and exercise [2 Marks]

4 barrier: two from condom, diaphragm, IUD; hormonal: two from oral contraceptive, implant, some IUDs [2 Marks]

5 The relative risk of type 2 diabetes increases with the amount of sugar-sweetened soft drinks consumed. Sugar consumption is a risk factor for type 2 diabetes. [3 Marks]

6a follicle stimulating hormone (FSH) [1 Mark]

6b luteinising hormone (LH) [1 Mark]

7 because enzymes and other cell functions work optimally at a specific body temperature [1 Mark]

8 by diet and exercise [1 Mark]

9 Hormonal methods of contraception use reproductive hormones (oestrogen and progesterone or progesterone only) to prevent pregnancy. These contraceptives inhibit the release of the pituitary hormones that control egg maturation and release. They also thicken cervical mucus, which helps to prevent sperm reaching an egg. [3 Marks]

10 Meeting 0% of physical activity guidelines compared with meeting 50% leads to an increased risk of mortality. This risk increases in people who are more than normal weight. There is a slight reduction in risk for people who are overweight rather than obese or very obese. [3 Marks]

11a the regulation of the internal conditions in the body [1 Mark]

11b The nervous system communicates rapidly using electrical impulses carried by nerve cells to specific effectors. The endocrine system coordinates slower but longer-lasting responses using hormones, carried around the body in the blood. [4 Marks]

12 Follicle stimulating hormone (FSH) and luteinising hormone (LH) [2 Marks]

13 In endometriosis the cells that make up the menstrual lining in the uterus are found in other places within the abdomen. These cells respond to the female reproductive hormones in the same way as cells in the uterine lining. From about day 4 in the menstrual cycle the lining builds up in response to increasing concentrations of oestrogen until ovulation at around day 14, when the concentrations of oestrogen start to decline. Until around day 28 the lining is maintained while the concentrations of progesterone increase and reach a peak. Once the concentrations of both oestrogen and progesterone have fallen, the lining begins to break down, causing pain and discomfort in the abdomen. Doctors could treat endometriosis by administering oestrogen and progesterone, which would prevent the lining from building up further and the existing lining from beginning to break down. [6 Marks]

14 The percentage of adults who smoke decreased from 1950 to 2010. The percentage of men and women smoking in 2010 was roughly equal. The rate of lung cancer decreased in from 1970 to 2010 in men but increased gradually in women. There is a correlation between smoking and lung cancer in men, but appears not to be in women. [4 Marks]

[Total: 40 Marks]

Chapter 3.2 Radiation and risk

Lesson 3.2a Absorption and emission of radiation

1 11

2 Students' own diagrams, based on Figure 3.2.1, but with 2 electrons in the innermost energy level, 8 electrons in the middle energy level and 1 electron in the outermost energy level

3 They have jumped to a higher energy level in the atom.

4 energy from heating, electricity or electromagnetic radiation

5 mercury and sodium

6 The emission spectrum of neon is mainly in the red region of the spectrum, from 600 to 700 nm.

Lesson 3.2b Radioactivity

1 an atom with an unstable nucleus

2 the total number of protons and neutrons

3 Carbon has 6 protons and 8 neutrons. Nitrogen has 7 protons and 7 neutrons.

4a The nucleus loses 2 protons and 2 neutrons. The atomic number decreases by two.

4b One of the neutrons in the nucleus decomposes into a proton and an electron and the electron is emitted. The atomic number increases by 1, the mass number stays the same, and a new element is formed.

5 beta decay

6 Elements differ in their atomic number (number of protons in the nucleus). When the number of protons changes through radioactive decay, a new element is formed.

Lesson 3.2c Nuclear equations

1 Both equations have to be balanced.

2 A chemical equation shows what happens in a chemical reaction and a nuclear equation shows what happens when there are changes in the nucleus.

3a $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$

3b $^{219}_{86}Rn \rightarrow {}^{215}_{84}Po + {}^{4}_{2}He$

4a $^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}e$

4b $^{32}_{15}P \rightarrow {}^{32}_{16}Y + {}^{0}_{-1}e$

5a $^{24}_{11}Na \rightarrow {}^{24}_{12}Mg + {}^{0}_{-1}e$

5b beta particle

6a alpha radiation

6b A = 228, Z = 88

7a Platinum-190 → osmium-186 + helium nucleus

$^{190}_{86}Pt \rightarrow {}^{186}_{84}Os + {}^{4}_{2}He$

7b Rhenium-187 → tantalum-183 + helium nucleus

$^{187}_{86}Re \rightarrow {}^{183}_{84}Ta + {}^{4}_{2}He$

7c Copper-66 → zinc-66 + electron

$^{66}_{29}Cu \rightarrow {}^{66}_{30}Zn + {}^{0}_{-1}e$

7d Nickel-66 → copper-66 + electron

$^{66}_{28}Ni \rightarrow {}^{66}_{29}Cu + {}^{0}_{-1}e$

7e Rhodium-105 → palladium-105 + electron

$^{105}_{45}Rh \rightarrow {}^{105}_{46}Pd + {}^{0}_{-1}e$

7f Osmium-186 → tungsten-182 + helium nucleus

$^{186}_{76}Os \rightarrow {}^{182}_{74}W + {}^{4}_{2}He$

Lesson 3.2d Half-life

1 When a particular nucleus in a radioisotope will decay is not predictable.

2 the average time it takes for half of all the nuclei present in a radioactive sample to decay, or the time it takes for the count rate (activity) to halve

3a 40 counts per second

3b 20 counts per second

3c 10 counts per second

3d 5 counts per second

4 8 minutes

5a/5b Student's own graphs of activity, using the data from the table on page 231 of the Student Book, with a line of best fit drawn correctly as a smooth curve

5c 1 minute

6 2 hours

7 1/192

8a ¼

8b No, because the activity decreases too rapidly for the lifetime of the product.

Lesson 3.2e Maths skills: Drawing and using lines of best fit

1 200 to 100 counts/second = 70 seconds; 100 to 50 counts/second = 70 seconds; 200 to 100 counts/second = 100 seconds. Average = 80 seconds.

2a Students' own graphs, based on the data in the table on page 233 of the Student Book

2b 30 minutes

3a 40 counts/second

3b 1/16th

4a 112.5 counts/second

4b 1/16th

5 6 hours

Lesson 3.2f Penetration properties of radiation

1 Beta particles can pass through air and paper but are completely absorbed by a sheet of metal, such as aluminium, just a few millimetres thick.

2 gamma rays

3 a charged atom

4 because the numbers of electrons in its nucleus have changed (in this case it has lost an electron)

5 Beta particles are much smaller than alpha particles and have a smaller charge, so they do less damage.

6 because they have they largest mass and are stopped easily by the air

Lesson 3.2g Contamination and irradiation

1 the unwanted presence of radioactive atoms

2 Contamination occurs when people swallow or breathe in radioactive materials. They can also enter the body through an open wound or be absorbed through the skin.

3 The exposure of an object to radiation from an outside source.

4 any sensible idea, such as from the sky, the air, the soil and from building materials

5 An irradiated object does not become radioactive, whereas a contaminated object could do. Irradiation can cause ionisation, which damages body cells. Contamination is a hazard because radioactive nuclei emit harmful ionising radiation as they decay. If a contaminant enters the body, the ionising radiation can severely damage living cells. It is often difficult to remove the contaminant, so it continues to add to the dose for as long as it emits radiation.

6 His contamination was from alpha particles inside the body.

7 Yes. Alpha particles have high mass and cause massive short-range damage.

3.2h Ionising radiation

1 a change in DNA

2 premature skin aging, cataracts and skin cancer

3 Alpha particles have the most ionising power but the least penetrating power. Gamma rays are the most penetrating but have the weakest ionising power. However, the risk of harm is greater the bigger the effective dose from exposure to radiation. So, if someone is exposed to large amount of radiation from a highly active alpha source, the risk of harm could be greater than someone exposed to much smaller amount of radiation from a low activity gamma source.

4 1 in 3000

5 Kevin is at greatest risk of harm as Gillian would be shielded from radiation at work, whereas Kevin is not. The exposure dose should be measured with a dose meter to access the risk.

6 any sensible answers, UV radiation levels are increased at higher altitudes

Lesson 3.2i Cancer

1 uncontrolled cell division

2a UV light and other ionising radiation

2b smoking

3 Benign tumours grow slowly, whereas malignant tumour cells divide rapidly. Benign tumours do not spread and are harmless, whereas malignant tumours can invade tissues around them and spread via the blood

to different parts of the body, where they form secondary tumours.

4 quit smoking, lose weight, avoid excessive sun/UV exposure, drink alcohol in moderation, have a healthy diet, exercise

5 Cancer starts when a genetic mutation occurs and a cell starts to multiply out of control, forming a tumour.

6 Mutations in genes may be triggered by ionising radiation, but cancer cells can be destroyed by exposure to extremely large amounts of radiation.

End of chapter questions

1 Students' own diagrams, based on Figure 3.2.1 on page 224 in the Student Book [1 Mark]

2 alpha, beta and gamma [2 Marks]

3 the average length of time for half the nuclei in a radioactive sample to decay, or the time it takes for the count rate (activity) to halve [1 Mark]

4 When a particular nucleus in a radioactive sample will decay is not predictable. [2 Marks]

5 Irradiation with X-rays or gamma rays is used in radiotherapy to treat cancer, and in hospitals, food for seriously ill patients is sometimes sterilised using gamma rays. However, large doses can cause genetic mutations and cancer. [2 Marks]

6 4 years. 4 days is too short, and the activity would decrease too rapidly; 400 years exceeds the lifetime of the product. [2 Marks]

7 The number of protons in the nucleus of its atoms. [1 Mark]

8 a Geiger–Müller tube [1 Mark]

9 Penetrating power is the ability to pass through materials. Ionising power is the amount of power available to knock electrons out of atoms and create ions. [2 Marks]

10a 23 = mass number (number of protons and neutrons); 11 = atomic number (number of protons) [1 Mark]

10b an atom with an unstable nucleus that randomly undergoes radioactive decay, emitting alpha particles, beta particles, neutrons, or electromagnetic radiation as gamma rays [1 Mark]

11a Iodine-131 has a half-life of 8 days and is a better tracer as we would need the activity to drop quickly. A short half-life is best to minimise the patient's exposure to ionising radiation. [2 Marks]

11b Risks: The patient is exposed to ionising radiation, which may cause mutations. Advantages: They are a good way to monitor the biological processes in the body. [2 Marks]

12 change in the DNA of a gene [1 Mark]

13 An irradiated object does not become radioactive. A contaminated object could potentially become radioactive. Irradiation can cause ionisation, which damages body cells. Contamination is a hazard because radioactive nuclei emit harmful ionising radiation as they decay. If a contaminant enters the body, the ionising radiation can severely damage living cells. It is often difficult to remove the contaminant, so it continues to add to the dose for as long as it emits radiation. [1 Mark]

14 $^{219}_{86}Rn \rightarrow {}^{215}_{84}Po + {}^{4}_{2}He$ [2 Marks]

15 20 minutes [2 Marks]

16a The graph plotted from actual measurements would not be a smooth curve. [2 Marks]

16b 8 minutes [2 Marks]

17 Students' own tables, showing that alpha particles are the least penetrating form of ionising radiation and gamma rays are the most ionising [3 Marks]

18 The emission spectrum for each element shows the wavelengths of radiation emitted by an element as sharp lines of different colours and has a distinctive pattern. [3 Marks]

19 Irradiation of food does not make the target radioactive, but contaminated food would contain radioactive nuclei that would emit harmful radiation and cause severe damage to living cells if it entered the body. [4 Marks]

[Total 40 Marks]

Chapter 3.3 Preventing, treating and curing diseases

Lesson 3.3a Spread of communicable diseases

1 a microorganism that causes a communicable disease

2 The pathogen may be transferred via the skin to other surfaces and people.

3 Pathogens such as bacteria secrete toxins and viruses cause damage that makes us feel ill. These symptoms include high temperatures, nausea, headaches and rashes.

4 by simple hygiene, such as covering the mouth when coughing, using a handkerchief when sneezing and washing hands after using the toilet; also isolation of infected individuals, destroying vectors and by vaccination

5 Ebola haemorrhagic fever (EHF) control measures are reducing the risk of contact with infected animals such as bats, wearing protective clothing, washing hands frequently, isolation of infected people, safe burials of the dead, and travel restrictions. These worked to stop the epidemic. Reducing the risk of contact with infected animals such as bats and wearing protective clothing was not possible for the general population. Other measures would be applicable.

Lesson 3.3b Viral diseases

1 by entering living cells and using the cell's own process to make copies of the viral genetic material and proteins to create many new viruses

2 EHF: fever, headache, diarrhoea, nausea and rashes; cold virus: runny nose, sore throat and cough

3 HIV is spread by contact with contaminated bodily fluids such as blood or semen. Suggested control measures: the use of condoms, not sharing needles, the administration of antiretroviral drugs.

4 Measles is spread by through the air, by expulsion of tiny droplets that carry the virus while talking, coughing and sneezing. It is controlled by vaccination of young children.

5 Late-stage HIV, or AIDS, occurs when the body's immune system is weakened by the HIV virus and is no longer able to deal with other infections or cancers.

6 Bacteria are living cells that survive outside body cells and can be treated with prescribed drugs, but viruses are only found inside host cells, where they are protected from drugs.

7 Measles is spread by droplets in the air, whereas HIV is spread by exchange of bodily fluids. The spread of measles is more infectious because it is by an airborne route and therefore can infect more people more quickly.

Lesson 3.3c Bacterial diseases

1 any bacterial disease, such as gonorrhoea, *Salmonella* food poisoning, tuberculosis, anthrax, whooping cough, Lyme disease, gas gangrene, diphtheria, bacterial meningitis, Legionnaire's disease, typhoid

2 *Salmonella* food poisoning: fever, abdominal cramps, vomiting, diarrhoea. Gonorrhoea: thick yellow or green discharge from the vagina or penis, pain when urinating

3 eating food that is contaminated with *Salmonella* bacteria or preparing food in unhygienic conditions, e.g. using contaminated knives or chopping boards

4 Treatment with antibiotics, use of a barrier method of contraception, such as a condom, to prevent contact.

5 The cases of *Salmonella* were higher between the beginning of May and the end of September. Any suitable suggestions why, including the bacterium may grow more rapidly in warmer conditions during the summer months, more cases developed as the processed foods were sold and eaten a few months after the initial outbreak.

6 Knowledge of how bacteria are spread enables preventative measures to be put in place and treatments to be developed.

7 Bacteria are living things that survive outside body cells, unlike viruses, which are only found inside host cells, and are protected from drugs there. Bacterial diseases can be treated with antibiotics, whereas protection from viral diseases is by vaccination.

Lesson 3.3d Defence against pathogens

1 The skin acts as a barrier and produces antimicrobial secretions via glands in the skin. The nose traps particles that may contain pathogens. The trachea and bronchi secrete mucus, which traps pathogens. The stomach produces acid, which kills the majority of pathogens that enter via the mouth. Platelets (cell fragments in your blood) start the clotting process at wound sites. Clots dry to form scabs, which seal the wound.

2 stomach acid

3 They spread thousands of tiny liquid droplets that may contain pathogens into the air.

4 It acts as a barrier. The outer layer of skin cells is dry and dead so that pathogens cannot easily penetrate cells. The skin produces antimicrobial oils via sebaceous glands. When the skin is cut, platelets in the blood are exposed to the air at the wound site. They make protein fibres (fibrin) that form a mesh over the wound. The platelets and red blood cells get caught in the fibres to form a clot.

5 The trachea and bronchi have a thin lining of tissue with lots of ciliated cells. Goblet cells in the lining produce mucus, which traps smaller dust particles and microbes. Cilia beat together to waft mucus to the back of the throat, where it is swallowed. Ciliated cells have many mitochondria to supply the energy needed to do this.

6 They are not able to clear pathogens as easily, as the damaged cilia cannot move mucus containing pathogens out the lungs.

3.3e The human immune system

1 White blood cells recognise and destroy pathogens that enter the body. They ingest pathogens and produce antibiotics and antitoxins.

2 Phagocytes can leave the blood by squeezing through capillaries to enter tissues that are being attacked. A phagocyte moves towards a pathogen and surrounds it with a sleeve of cytoplasm, eventually containing it in a vacuole, where enzymes digest and kill the pathogen.

3 Antitoxins combine with the toxins to neutralise them. Antitoxins are specific to particular toxins.

4 Antibodies are produced by lymphocytes when they recognise that pathogens are present. The antibodies cause the pathogens to burst, bind to the pathogens and destroy them, and cover the pathogens, sticking them together. Phagocytes then ingest them. If the same type of pathogen enters the body again, lymphocytes recognise it and immediately make lots of antibodies against it.

5 Antitoxins produced by white blood cells bind to toxins produced by pathogens and neutralise them. The pathogens are stuck together by antibodies, and the clumps are then ingested by phagocytes.

6 HIV attacks the white cells in the blood that help to control the response of the immune system to pathogens. Damage to the immune system by HIV exposes affected people to a variety of simple infections that can kill, such as tuberculosis and pneumonia.

Lesson 3.3f Vaccination

1 Vaccination is the introduction of a small quantity of an inactive or dead form of a pathogen into the body to protect it from disease.

2 In response to the vaccine, lymphocytes produce antibodies to fight the 'infection' without causing illness. When live pathogens of the same type infect the body, the immune

system recognise them and start to protect it immediately.

3a Lymphocytes 'remember' the shape of the pathogen antigens, so when a live pathogen enters the body, the lymphocytes instantly recognise it because it has the same antigens as the vaccine.

3b No, antibodies lock onto the pathogens and kill them before they have a chance to make the person feel ill.

4 Mass vaccination programmes increase the number of people who are immune to a pathogen, making it difficult for the pathogen to pass to people who are not immunised. If a large proportion of the population is immune to a pathogen, its spread is very much reduced.

5 Flu viruses frequently mutate into new strains. The lymphocytes do not recognise the new strains, so new vaccines have to be made each year.

6 Any sensible discussion points, including: Global vaccination programmes are vitally important, because more people now travel around the world and could spread communicable diseases very easily from country to country.

Lesson 3.3g Medicines

1 A medicine is a useful drug that can help your body kill a pathogen or relieve the symptoms of an illness to make you feel better.

2 Antibiotics work inside the body to kill bacterial pathogens. Painkillers relieve the symptoms caused by infection.

3 Painkillers stop the sensory nerve endings sending pain messages to your brain via nerve impulses, so you feel little or no pain.

4 Antibiotics are used to treat bacterial infections. A prescribed course of antibiotics has the correct amount to kill the bacterial pathogen completely. Painkillers are used to relieve the symptoms.

5 The misuse or overuse of antibiotics has led to the emergence of strains of bacteria that are antibiotic resistant. Genes mutate in bacteria all the time, and by chance some mutations may make the bacteria resistant to an antibiotic. Not taking the whole course of antibiotics may mean that *all* the infecting bacteria are not killed. Any bacteria left will be more resistant than those killed first, and these resistant strains will then spread.

6 The resistance genes spread through the bacterial population, and populations of 'normal' bacteria are often reduced massively, leaving resistant strains to thrive. This means that the antibiotics soon become ineffective in killing the bacteria.

Lesson 3.3h Testing new drugs

1 Any from: digitalis from foxgloves, aspirin derived from a substance found in willow trees, penicillin from *Penicillium* mould, or any other suitable answer.

2 to make sure that they are effective (able to prevent or cure a disease, or make you feel better) and that they are safe (not too toxic or with undesirable side effects)

3 Preclinical testing in laboratories (using cells, tissues and live animals) to establish side effects and efficacy. Clinical trials, which use healthy volunteers and other patients. If the drug is deemed safe, further trials are performed to find the optimum dose.

4 to determine if they are safe and effective, to get an idea of the dosage

5 so that doctors and patients do not know during the trial whether the patients are taking the new drug or the placebo

6 The effect of feeling better because you think you're taking a medicine, even if you're not.

7 Doctors may be unconsciously influenced in reporting their results if they know which patients are taking the drug.

Lesson 3.3i Genetic modification

1 It has had some of its genes are changed; for example, it might have had the human gene for insulin transferred to it so that a product can be made for human use.

2 The bacteria are grown in fermenters so that large amounts are produced. The protein can easily be removed, processed and purified.

3 Any sensible pros and cons, such as:
Pros: one genetically modified goat can produce the same amount of antithrombin in a year as 90 000 human blood donations.
Cons: transgenic mammals have to be created by micro-injecting foreign DNA into the nucleus of a fertilised egg, which is then implanted into a surrogate mother.

4 Any sensible risks and benefits, properly evaluated, such as:
Risks: tissue may be rejected by the human immune system
Benefits: it could help save thousands of human lives each year

5 Any sensible arguments for and against, such as:
For: many organs for transplant could be provided per year, which is ethically justifiable because of the people that will be helped and lives saved.
Against: animals should not be used in this way, as all life is sacred.

Lesson 3.3j Stem cells

1 embryos that are a few days old, umbilical cord blood, adult bone marrow

2 any sensible answer, such as to replace dying or damaged cells

3 any two from: cancers such as leukaemia, spinal injuries, Alzheimer's disease, Parkinson's disease, multiple sclerosis, Type 1 diabetes, heart disease

4 The treatment kills healthy stem cells in the bone marrow as well as the leukaemia cells. Healthy cells can be replaced, which helps stimulate new bone marrow growth, supplies new blood cells and restores the immune system.

5 any sensible objection, such as: some people argue that life begins at conception, so an embryo has rights and its life should not be ended

6 Any sensible benefits and drawbacks, properly evaluated, such as:
Benefits: stem cells could be cultured in limitless numbers to cure diseases and repair damaged tissue.
Drawbacks: the risk that the ability of stem cells to proliferate could lead to cancer when they are transplanted into a patient.

Lesson 3.3k Maths skills: Sampling and scientific data

1 interactions between physical and mental health effects; severe or prolonged ill health can lead to depression and other mental illnesses

2 one from: defects in the immune system mean that an individual is more likely to suffer from infectious diseases; immune reactions initially caused by a pathogen can trigger allergies; viruses living in cells can be the trigger for cancers

3 HIV interferes with the immune system, which means that people with AIDS have an increasing risk of opportunistic infections, because their bodies are not able to fight off invading pathogens such as tuberculosis.

4 The graph shows that HPV is responsible for triggering large numbers of cases of cancer in both men and women, worldwide. The most common cause of cancer triggered by HPV in men is throat cancer. The most common cause of cancer triggered by HPV in women is cervical cancer.

5 Cancer is not a disease that can be transferred from person to person, but an infection may alter the DNA in a cell that makes it start to divide uncontrollably, leading to cancer.

Lesson 3.3l Sampling and scientific data

1 because it is not possible to study every individual in a population

2a (a) 50% (b) 75% (c) 89% (d) 89%

2b The more consistent results are given with the larger sample size.

3 The sampling technique used can affect the outcome.

4a 3 (5–10%) or 6 (square root)

4b 13 (square root) or 16 (5–10%)

4c 27

4d 369

5 Bias results from systematic errors in procedure, which can give false outcomes. Bias can be minimised by choosing samples randomly, using a control group that is similar to the test group, and double-blinding the trial so that neither the patients nor the doctors can tell which are the test or the placebo drugs.

6a the choice of patients was not from the population at large, just the population from the hospital database; the number of patients sampled was too low

6b increase the number of patients chosen, and choose them randomly from the whole population

6c 176

End of chapter questions

1 an organism that transfers a disease-causing pathogen from one host to another but does not cause the disease itself [1 Mark]

2a The stomach produces acid, which kills the majority of pathogens that enter via the mouth. [1 Mark]

3 fungus [1 Mark]

4 any protist disease, e.g. malaria, Chagas disease, sleeping sickness, giardiasis [1 Mark]

5 white blood cell, lymphocyte [1 Mark]

6 4×10^9 [1 Mark]

7a the process in which a pathogen is engulfed and ingested by a type of white blood cell [1 Mark]

7b the engulfing and ingesting of a bacterium by a phagocyte [1 Mark]

8 to check if they are safe and effective and to work out the correct dose [2 Marks]

9 dead or attenuated forms of a pathogen or a similar pathogen [1 Mark]

10 any two of: skin producing antimicrobial secretions, the nose trapping particles that may contain pathogens, the stomach producing acid, which kills the majority of pathogens that enter via the mouth, platelets starting the clotting process at wound sites [2 Marks]

11 Late-stage HIV, or AIDS, occurs when the body's immune system is no longer able to deal with other infections or cancers. [2 Marks]

12 any one sensible answer, such as: genetically modified bacteria may escape into the environment and cause harm; it's wrong to use animals to produce transplant organs and for production of drugs [1 Mark]

13 Young children can be vaccinated against the disease; their lymphocytes detect specific antigens on the virus and produce antibodies against them; then if the virus enters their body at some future date the lymphocytes will instantly recognise it and produce antibodies against it so quickly that the person will not become ill. [3 Marks]

14 Painkillers stop the sensory nerve endings sending pain messages to the brain via nerve impulses. [1 Mark]

15 An antibody is specific because its shape will only fit one shape of antigen. [1 Mark]

16 Antibiotics work by interfering with various processes in bacterial pathogens and killing them. They have no effect on viruses. [2 Marks]

17 because the viruses are present inside host cells, where they are protected from drugs; some viruses mutate frequently, so new vaccines have to be made each year [2 Marks]

18a 568 – 483 = 85; 568 ÷ 85 = 6.67. Chance is 1 in 6.67, or 15%. [1 Mark]

18b The results may be different for people of different ages. University students are a small group of relatively young patients in whom antibiotic-resistant bacteria may not have spread. [2 Marks]

18c that the results don't represent the true situation; one from: choosing samples randomly, choosing a control group with

similar characteristics as the sample group, using a double-blind trial [2 Marks]

19a an unspecialised cell that can differentiate into many different cell types [1 Mark]

19b (i) 51% [1 Mark] (ii) 40%; [1 Mark] (iii) 9% [1 Mark]

19c The newspaper was incorrect as though 51% of patients showed an improvement, and only 9% became worse, the paper does not mention that improvement was mainly in patients with Type 2 diabetes and had less effect in patients with Type 1 diabetes. So the newspaper should have said that it was a success for patients with Type 2 diabetes, but not for patients with Type 1 diabetes. [2 Marks]

20 The number of patients with MRSA infections increased from 1993 to 2005, even though they were treated with antibiotics. Therefore the spread of the MRSA strain increased with time. [4 Marks]

[Total: 40 Marks]

Topic 4 Explaining change

Chapter 4.1 The Earth's atmosphere

Lesson 4.1a The early atmosphere

1 During the first billion years of the Earth's existence there was intense volcanic activity that released gases. The atmosphere has changed from possibly hydrogen and helium at first, probably followed by gases from volcanic activity to finally an atmosphere rich in oxygen, which is what we have now.

2 The gases vented out of volcanoes meant that the atmosphere consisted of mainly carbon dioxide with little or no oxygen gas. Volcanoes also produced nitrogen, which gradually built up in the atmosphere, and there may have been small proportions of methane and ammonia.

3 There is only indirect evidence. The idea is based on the composition of gases vented out in present-day volcanic activity, which may not be correct. An assumption is made that the same proportion of gases is given out today as was given out by volcanoes billions of years ago. Another set of evidence is gained by measuring carbon and boron isotope ratios in sediments under the sea.

4 because they believe that there was intense volcanic activity that released gases

5 Counting the number of stomata on fossils of ancient leaves makes assumptions about the levels of carbon dioxide in the atmosphere. Evidence from direct measurements would seem more valuable but there is not always agreement that the measurements were taken correctly.

6 The number of stomata should be proportional to the amount of carbon dioxide in the atmosphere, as higher levels of carbon dioxide would require plants to have more stomata for gas exchange.

Lesson 4.1b Changes in the atmosphere

1 about 2.7 billion years ago

2 Anaerobic life does not need oxygen, whereas aerobic life does.

3 glucose

4 Algae and plants released oxygen into the atmosphere as a product of photosynthesis. The oxygen was not used by other organisms and therefore levels increased.

5 As more plants evolved the levels of carbon dioxide went down and the levels of oxygen went up.

6 As plants died and decayed, they formed a thick layer of plant deposits, which was compressed first to peat and then eventually into coal.

7 Coal is mostly carbon that became locked in the ground, which resulted in lower concentrations of atmospheric carbon dioxide. Plankton were deposited in muds on the sea floor and were covered over and compressed over millions of years. This produced crude oil and natural gas, which became locked in the

rocks, also trapping carbon and reducing atmospheric carbon dioxide concentrations.

Lesson 4.1c The carbon cycle

1 respiration by plants, animals and decomposers and combustion of fossil fuels and wood

2 Carbon dioxide in the air is taken up by living plants in photosynthesis and carbon is stored in the ground and the ocean. Carbon dioxide is released back into the air through respiration, the decay of dead organisms, the burning of fossil fuels, volcanic eruptions and forest fires.

3 The carbon cycle is important because carbon is a vital component of all living organisms.

4 The processes involved in the carbon cycle are photosynthesis (creating glucose and oxygen from carbon dioxide and water), respiration (creating carbon dioxide, water and energy from glucose and oxygen), decomposition (breaking down of dead animal and plant matter), the creation of fossil fuels from compressed dead animal and plant matter and the creation of limestone rocks from the compressed remains of marine organisms over millions of years.

5 Microorganisms are decomposers, which break down the smaller pieces of dead material, releasing waste carbon dioxide, water, heat and nutrients. Decomposers decay waste in compost heaps and sewage works.

6 Enzyme action depends on heat so warmth speeds up decay.

Lesson 4.1d The greenhouse effect

1 any two of: water vapour, carbon dioxide, methane

2 These gases allow radiation from the Sun to pass through and warm the Earth's atmosphere, some of it becoming trapped by the greenhouse gases in the air. In this way, the greenhouse gases in the atmosphere maintain the temperatures on Earth high enough to support life.

3 Short-wavelength solar radiation enters the Earth's atmosphere from the Sun. The radiation that is reflected back from the Earth, by contrast, is long-wavelength radiation. Students' own diagrams, based on Figure 4.1.12 on page 287 in the Student Book.

4 The average temperature will be higher on Venus than expected given its distance from the Sun, because its atmosphere is composed of carbon dioxide, which is a greenhouse gas. The greater the amount of carbon dioxide in the atmosphere, the more heat energy is absorbed.

5 If there were no greenhouse gases, the Earth would be colder than it is now and would not support life.

Lesson 4.1e Human impacts on the climate

1 any two from: human activity, including increased combustion of fossil fuels such as coal, and deforestation, which both release carbon dioxide and methane into the atmosphere

2 Plants remove carbon dioxide from the air for photosynthesis. When trees are cut down it reduces the biomass available for this, and decomposition of plant matter also release the carbon dioxide back into the atmosphere.

3 burning fossil fuels, deforestation, farming and waste in landfill sites

4 an increase in the average global temperature, leading to extreme weather events, melting of the polar ice caps and rising sea level, flooding low-lying areas and eroding coasts

5 plot the amount of methane produced by agriculture over the last 50 years and plot the change in average global temperature over the same time period to see if there is a correlation

6 Complex systems need to be modelled to access the effects of global climate change. When the models are presented to the public they are simplified to make them easier to understand and to fit into a short news item.

As a result, speculation and opinions may be presented in the media based on only parts of the evidence complex interpretations and also might be biased.

Lesson 4.1f Effects of climate change

1 Weather patterns are short-term changes in weather, whereas a climate change is a long-term change in the whole weather system across the world.

2 any sensible answer, such as glaciers are mountain reserves of fresh water that are frozen, and fresh water is essential to life on Earth

3 Temperature stress for humans and wildlife (some areas will become too hot for people to make a living). Water stress for humans and wildlife (fresh water supplies will reduce in some regions). Changes in the food-producing capacity of some regions (the production of wheat and maize will be affected).

4 Changes to the distribution of wildlife species (migration patterns are changing). For example, some animals such as possums are vulnerable to increases in environmental temperature because they cannot maintain their body temperature and may become extinct. Coastal birds' nests are vulnerable to flooding, so numbers may decrease.

5 Students' own evaluations, including the effects on coastal mangrove forests, which are undermined and deprived of nutrients by increasing numbers of storms and typhoons, and coral reefs, where coral bleaching occurs as a result of increasing sea temperatures.

Lesson 4.1g Mitigating the effects of climate change

1 Using electricity to power the computer and play the game contributes to a carbon footprint, as does the creation of the game and the computer in the first place.

2 because carbon footprints are high and are contributing to global warming

3 Solar energy is an alternative energy source. Its production does not involve burning fossil fuels.

4 Use of solar energy panels reduces the carbon footprint, but some energy was used in making the panels.

5 Cavity wall insulation, double glazing (windows), loft insulation (roof): stop energy loss from the house so less energy has to be produced to heat it. Solar panels: use the Sun to produce energy instead of burning fossil fuels. Low-energy light bulbs and switching off appliances: use less electricity. Setting the thermostat low: less energy is used to heat the house. Hot water tank jacket: heat is not lost from the tank, so less energy is needed to heat the water.

6 Forestation increases the carbon sink so more carbon dioxide is absorbed from the air and is replaced with oxygen. Carbon dioxide is captured and stored by planting trees that use the equivalent amount of carbon dioxide as is produced by electricity use. The idea is to produce a zero carbon footprint.

Lesson 4.1h Air pollution

1 any three from: carbon monoxide, sulfur dioxide, oxides of nitrogen, solid particles, unburned hydrocarbons

2 If combustion occurs when the supply of air or oxygen is poor, water is still produced, but carbon monoxide and carbon are produced instead of carbon dioxide.

3 It is a toxic gas that combines very strongly with haemoglobin in the blood. At low doses it puts a strain on the heart by reducing the capacity of the blood to carry oxygen. At high doses it makes people lose consciousness or even die.

4 Sulfur dioxide is produced by burning fuels that contain some sulfur. These include coal in power stations and some diesel fuel burned in ships and heavy vehicles. Sulfur dioxide turns to sulfuric acid in moist air. Along with oxides

of nitrogen, sulfuric acid dissolves in rain water and is called acid rain.

5a by damaging the lungs, and by entering the bloodstream and becoming lodged in the body, causing heart attacks and DNA mutations

5b Reduction in particulate emission would improve air quality and reduce the amounts of smog and soot.

Lesson 4.1i The water cycle

1 bodies of permeable rock that can contain or transmit groundwater

2 The other 99.7% of total water is in the oceans, soils and ice caps and floating in the atmosphere.

3 Water from the oceans evaporates, condenses to form clouds, moves over high ground and precipitates (rains, snows, sleets or hails) water back to the ground to rivers, lakes and aquifers.

4a water vapour

4b snow or ice crystals, ice

Lesson 4.1j Required practical: Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation

1 10 for each section

2 collect river water samples and analyse them with pH meter/pH paper or similar

3 What are the concentrations of lead, sewage (dairy farm), and calcium content in the different stretches of river water?

4 Water turns to water vapour when the temperature reaches its boiling point.

5 The condenser cools the water vapour so that it turns back to a liquid.

6 Distillation turns water to water vapour when heated to boiling point; water vapour is condensed to pure water; the salts remain in the flask.

7 to check the temperature of the water and to check the purity of the water

8 The boiling point of salt is much higher than that of water. Eventually, the salt concentration becomes supersaturated and crystallises.

9 to keep the flow rate constant and not determined by gravity

10 The boiling points of all samples decreased after distillation. The boiling point of pure water is 100 °C. All of the samples have higher boiling points than that, so none of the samples is pure. Sample 3 is the purest, sample 3 is the least pure. Other impurities carried over may be present in the samples.

11 Take replicate samples from each site and take the average of the results. As dairy farms and lead mines produce pollutants, the site should be placed downstream of these. So samples should be taken only at A and C, to compare before and after the pollution.

12 insulation of the condenser to reduce energy loss; the samples could be more vigorously heated to a higher temperature; the samples could be redistilled to increase the purity

13 salinity content, lead content, bacterial content

14a 102 °C before; 101.3 °C after

14b Average boiling points are more useful to overcome any variation in the samples.

14c The average is more useful to avoid variation in sampling. But separate samples are also useful to see the range of results in case some are anomalous.

Lesson 4.1k Sources of potable water

1 Water falls as rain and collects in the ground and in lakes and rivers and is then treated to make it potable. This treatment involves: sedimentation of particles so that solids clump together and drop to the bottom; filtration of very fine particles using sand and sterilising to kill microbes; addition of sterilising agents such as chlorine, ozone or ultraviolet light.

2 Microbes could increase in numbers in the earlier stages of treatment, so best to sterilise last.

3 This water is not potable because it contains over the maximum allowed levels of bacteria.

4 Spain has less fresh water than the UK, and therefore needs more desalination plants to produce drinkable water.

5 Distillation and reverse osmosis processes require large amounts of energy, so are very expensive.

6 In sedimentation, solid particles clump together and drop to the bottom. Fine particles would take longer to sink than large particles.

7 Urban lifestyles produce large amounts of waste water from domestic washing machines, dishwashers and showers and sewage that requires treatment before being released into the environment. Therefore, organised waste water management is necessary otherwise diseases such as typhoid or cholera could occur.

Lesson 4.1l Maths skills: Use ratios, fractions and percentages

1a 95% carbon dioxide; 5% other gases

1b carbon dioxide : other gases 19 : 1

2 75% methane; 25% ammonia

3 14.38 °C; 13.62 °C in 1880, so 0.76 °C higher

4 After 2009 the world population rose to over 7 billion. The total crop yield/tonnes also increased to 55 000 billion. There are no data to show that this crop yield will not feed the world's population, but the threat of malnutrition may exist as the population is rising faster than the increase in crop production.

5 3 orders of magnitude

End of chapter questions

1 A sulfur dioxide [1 Mark]

2 D methane [1 Mark]

3 Carbon dioxide was taken up by plants in photosynthesis and fixed in the soil when the plants decayed. Carbon dioxide was replaced by oxygen from plants. [2 Marks]

4 B global warming [1 Mark]

5 C chlorination [1 Mark]

6 two of: solar panels, double glazing, insulation, trees around the house; any other suitable answer [2 Marks]

7

ppm CO_2	27	31	35	37	Increase in acid rain
ppm NOx	3.6	4.4	5.2	5.6	Increase in greenhouse gas
°C	12	12.5	12.9	13.1	Increase in global warming

[2 Marks]

8 by distillation or membrane filtration methods such as reverse osmosis [2 Marks]

9 carbon monoxide and carbon particulates [1 Mark]

10 Short wavelengths enter the atmosphere and long wavelengths are given out. [1 Mark]

11 Carbon dioxide is one of the waste products of respiration and is released into the atmosphere. [2 Marks]

12 Anaerobic bacteria break down the smaller pieces of waste material in sewage. [2 Marks]

13 In 10 years' time the glacier ice may start to melt into water. [2 Marks]

14 Incoming radiation from the Sun is short wavelength and is not absorbed by the atmosphere. Outgoing radiation is longer wavelength and is absorbed by the greenhouse gases (water vapour, carbon dioxide and methane) in the atmosphere, causing warming. [2 Marks]

15 coal, calcium carbonate in seashells, limestone rock, the bodies of living organisms, decayed plants and animals in the soil, carbon dioxide in the air

Shells of marine organisms contain carbonates. Corals and microscopic algae cover themselves with calcium carbonate. Shells of dead organisms fall to the sea floor. Over millions of years they are compressed to form limestone. Limestone rocks are eroded by water in the soil that contains dissolved carbon dioxide, which comes from the respiration of soil organisms. Carbon dioxide can be absorbed by oceans and held in a carbon sink. Living things are made up of

carbon. Plants take up carbon dioxide in photosynthesis. Decayed plant and animal in the soil are compressed over millions of years to form fossil fuels, which are combusted to release carbon dioxide into the air. [6 Marks]

16 NO_2 produced in the UK plateaued between 1970 and 1990 and then decreased. Levels of SO_2 have decreased from 1970 to 2010. Reductions in air pollutant emissions are due to regulatory controls for industry, domestic and transport sectors, switching from coal to gas power stations, reducing fuel use, changes to industrial processes, pollutant capture or conversion. Changes in behaviour to more sustainable transport. [2 Marks]

17 Reducing the carbon footprint by increasing the carbon sink through tree planting and reforestation. [2 Marks]

18 Plants need water to photosynthesise, along with carbon dioxide, in order to produce glucose and oxygen. Water vapour is a greenhouse gases in our atmosphere that allows radiation from the Sun to pass through and warm the Earth to a temperature at which life can survive. Fresh water is needed to irrigate crops and for drinking. In summary, water maintains habitats, maintains internal fluids and transport systems, is needed for chemical reactions and is a reactant in photosynthesis. [4 Marks]

19a It is a similar size and distance from the Sun as the Earth. [1 Mark]

19b 96.461% more [1 Mark]

19c Oxygen is produced by plants, which are not present on Venus. Venus is too hot to sustain life. [2 Marks]

[Total: 40 Marks]

Chapter 4.2 Ecosystems and biodiversity

Lesson 4.2a Habitats and communities

1 the interaction of a community of living organisms with the non-living parts of their surroundings

2 Students' descriptions of fish, coral and algae populations.

3 Humans eat both animals and plant material.

4a It increases.

4b It decreases.

5 The size of the predator population follows the size of the prey population. Large predator populations will deplete the prey until there are not enough prey for the predators to survive, so numbers of predators go down. For small predator populations the number of prey will increase, which will threaten the prey's foods supply, so prey numbers go down.

6 There is a lag in the population cycles because predator and prey take time to react to the changing population numbers.

Lesson 4.2b Interdependence and competition

1 Competition for space and resources affects the distribution and number of organisms, because they can only survive if they have sufficient resources for their needs.

2 Elephant seals compete for space, and males compete for females. Giraffes, gazelles and wildebeest compete for water and food. Cacti compete for water and minerals.

3 It they are not perfectly matched, one organism will become more successful than the other.

4 because there may be limited external resources

5 dependence between species in a community

6 The vole numbers would increase as there would be less competition for heather, and so the kestrel numbers would also increase. The stoat would change to eat only voles and the fox and short-eared owl populations would stay the same.

Lesson 4.2c Factors that affect communities

1 Abiotic: one from temperature, light intensity, oxygen levels for animals that live in water, carbon dioxide levels for plants, moisture levels, soil pH and mineral content for plants, wind intensity and direction. Biotic: one from food availability, new pathogens, new predators, competition between species.

2a Grass: light, carbon dioxide, soil pH and minerals, temperature, moisture levels, wind intensity and direction. Tropical fish: temperature, light intensity, oxygen levels for animals that live in water. Panda bear: temperature, moisture levels plus factors that affect plant growth for bamboo diet (light, carbon dioxide, soil pH and minerals, temperature, moisture levels, wind intensity and direction).

2b They could affect moisture levels, soil pH and mineral content for plants, along with wind intensity and direction by sheltering the grasses.

3 Rocky shore: temperature, light intensity, carbon dioxide levels for plants, moisture levels, soil pH and mineral content for plants, wind intensity and direction.
Splash zone: temperature, light intensity, oxygen levels for animals that live in water, moisture levels, soil pH and mineral content for plants, wind intensity and direction.
High-tide zone: temperature, light intensity, oxygen levels for animals that live in water, carbon dioxide levels for plants, moisture levels, soil pH and mineral content for plants, wind intensity and direction.
Mid-tide zone: temperature, light intensity, oxygen levels for animals that live in water, carbon dioxide levels for plants, moisture levels, soil pH and mineral content for plants, wind intensity and direction. Low-tide zone temperature, light intensity, oxygen levels for animals that live in water.

4 Limpets are aquatic snails with a shell that is broadly conical in shape and that are capable of locomotion instead of being permanently attached to a single spot. However, they need to resist strong wave action or other disturbances. They graze the algae attached to the rocks, so need to be higher up where algae grow. Sea anemones are predators that feed on small particles that are caught with the mucus secretion and moving water currents that are set up by their tentacles, so they need to be in the mid-tide zone to feed.

5 a community in which the biotic and abiotic factors are in balance so that population sizes remain fairly constant

6 percentage water content = (43.2 g – 21.89 g) ÷ 43.2 g × 100 = 49.3%

Lesson 4.2d Investigating the population size of a common species in a habitat

1a reduces aeration (amount of air) and irrigation (amount of water) in the soil

1b more difficult for roots to penetrate, less water in soil, physical damages of trampling

2 meristems – daisies unable to grow
leaves – daisies unable to photosynthesise
flowers – daisies unable to reproduce

3 The areas that are un-trampled will have fewer daisies due to competition with other plants for resources. Trampled areas will have more daisies because they are tougher than the other plants.

4 Make a transect line across each of the investigation areas with the tape, one at a time and place the quadrat every 5 m along the line, starting at 0 m.
In each placement of the quadrat, count the number of whole daisy plants completely within the quadrat. Count the number of daisy plants partially in the quadrat along two adjacent sides only. Add these numbers together and record them in a table.

5 The plant may not be in flower; the flower may be in the quadrat, but not the whole plant; to get a more accurate record of plants growing, not just those in flower.
12 (accept 11).

6 by adding all the daisy plants they found altogether and dividing by the number of quadrats – gives a plant density per m^2

7 The other student may have carried out a similar investigation, using a different transect. Pooling the results will make them more valid, and minimise the effect of any anomalies.

8 There are more daisies in the trampled area than in the un-trampled area.

9 Other plants (grass) out-competed the daisies for resources in the un-trampled areas. Trampling had more effect on the other plants, but daises are tougher – leaves not delicate, tough cuticle to withstand extreme temperatures and long fibrous roots (compacted soil less impact than for plants with shallow roots, able to reach deeper water reserves). When other plants died off due to trampling, daisies had more resources available, and so there were more of them.

Lesson 4.2e Biodiversity

1 a wide range of different plant and animal species living in an ecosystem

2 high-altitude mountainous terrain with low oxygen levels, little plant life and water running through: low biodiversity
deciduous forest with trees and bluebells: high biodiversity
freshwater pond, water plants, stones: low biodiversity

3 Areas of high biodiversity are important because they allow a wide variation of food sources to help a species to survive, provide us with food and other products such as timber, play a role in maintaining the atmosphere and water cycle.

4 All the requirements for living organisms to grow and survive are present in the ecosystem.

5 Huge areas of tropical forest are being destroyed to provide land for cattle and rice fields and to grow crops, such as oil palm and sugar cane to make biofuels. Mass destruction of trees has: increased the release of carbon dioxide into the atmosphere due to combustion and reduced the rate that carbon dioxide is removed from the atmosphere by photosynthesis.

6 Global warming might cause a small increase in the average global temperature. Some species, such as corals, are sensitive to small rises in temperature and might die, thus reducing biodiversity.

Lesson 4.2f Negative human impacts on ecosystems

1 Coastline erosion by the waves and snowstorms on mountains caused by wind may be a result of more severe weather events due to temperature change. Changes in the availability of water may lead to an increased need for farmland irrigation.

2a any one of: destruction of peat bogs, deforestation, or other suitable answer

2b freshwater pollution or other suitable answer

3 More of the Earth's resources will be used up, resulting in a decrease in the land available for other organisms.

4a Habitats are destroyed, including fewer nesting sites for birds.

4b Run-off into freshwater can pollute these systems. the nitrates and phosphates in the water increase and then algal growth increases. Algae cover the water surface and prevent light from reaching water plants. The plants and algae die. Bacteria respire as they break down dead plants and use up oxygen in the water. The other living organisms in the water die.

5 Algae have covered the water surface and are preventing light from reaching water plants. The plants and algae die. Bacteria respire as they break down the dead plants and use up the oxygen in the water, so other living organisms such as fish in the water die.

6 Peat is an important carbon store and is used as a fuel and as compost by gardeners. Peat bogs form over thousands of years in marshy areas. Peat is being destroyed faster than it is

being made. The loss of peat bogs reduces biodiversity.

7 The use of peat-free compost would prevent the destruction of peat bogs, and the different plants, animals and microorganisms that live there would survive.

Lesson 4.2g Positive human impacts on ecosystems

1 by introducing breeding programmes for endangered species; protecting and regenerating rare habitats; introducing wider field margins to provide habitat for many wild species; reducing deforestation and carbon dioxide emissions; using sustainable strategies, including replanting trees; recycling resources instead of dumping waste in landfill; cloning plant species to save them from extinction

2 They provide a habitat for a wide range of animals, birds and insects on land that is dominated by monoculture (one crop).

3 to protect endangered species, so that more plant species may be identified for medicines, to minimise damage to food chains and webs and to protect future food supplies

4 They save species from extinction and ensure genetic diversity is maintained.

5 ensuring long-term funding; having qualified scientists who understand the issues; animals and plants do not recognise boundaries; many organisations and governments may be involved, working locally, nationally and internationally; there is a lack of 'policing' of protected areas

6 The mangroves have increased due to massive planting programmes over the last two decades. The local environment agency worked with land developers and the public to maintain healthy, litter-free, sustainable forests.

7 Biodiversity protects species from environmental change and ensures natural sustainability for all life forms.

End of chapter questions

1 A population is the total number of one organism in an ecosystem, but a community is all the different species of plants and animals in an ecosystem. [1 Mark]

2 A quadrat is a square grid used to measure species in a defined area. [1 Mark]

3 a producer [1 Mark]

4 because they eat both plants and animals [1 Mark]

5 any two from: temperature, light intensity, oxygen levels for animals that live in water, carbon dioxide levels for plants, moisture levels, soil pH and mineral content for plants, and wind intensity and direction [2 Marks]

6 Bluebells need a lot of light to flower. They grow in woodland and compete for light with the trees, which would shade them if they were in leaf. [1 Mark]

7 the dependence between species for food, shelter, pollination and seed dispersal [1 Mark]

8 deforestation and removing peat from peat bogs [2 Marks]

9 the use of peat-free compost [1 Mark]

10 one type of crop grown year after year [1 Mark]

11 percentage water content = (58 g − 24 g) ÷ 58 g × 100 = 59% [2 Marks]

12a median = 3; mode = 4 [2 Marks]

12b mean number in a 1 m^2 area = 3.1
field is 20 m × 30 m = 600 m^2
number of daisies in the field is 600 m × 3.1 = 1860 [1 Mark]

12c to avoid any bias in sampling [1 Mark]

13 The rise in the human population follows the same pattern as the number of species becoming extinct, suggesting that there is a correlation between the two. Population numbers increased rapidly after 1950, and the number of extinctions increased rapidly after 1970. [2 Marks]

14 The numbers of field mice and rabbits would decrease because they would be eaten by larger number of foxes. The numbers of hawks

would then decrease as field mice are their only food supply. [2 Marks]

15 Carbon dioxide is taken up by plants during photosynthesis. Destruction of the rainforest without replanting means than there are fewer trees to photosynthesise and therefore levels of carbon dioxide in the atmosphere increase. [2 Marks]

16 Run-off of inorganic fertiliser into the pond would increase algae growth. Algae cover the water surface and prevent light from reaching water plants so they cannot photosynthesise. The fish lose their food source and die. [6 Marks]

17 Toxic chemicals from household and industrial waste taken to landfill sites can spread into soil and enter waterways. Toxins build up in food chains, kill organisms and affect feeding relationships, thus decreasing biodiversity. [2 Marks]

18 Use a quadrat, take several random samples and measure the area of moss in each 1 m^2 quadrat. Take the mean of all the reading for moss in all the samples, divide by lawn area in 1 quadrat and times by 100 to get the percentage. [2 Marks]

19 There is decrease in oxygen concentration 3 to 12 km (most severe at 7 km) downstream of the sewage outlet. Predict that there would be death of animals that live in the water. Investigate by measuring species numbers and diversity 3 to 12 km downstream of the sewage outlet. [4 Marks]

[Total: 40 Marks]

Chapter 4.3 Inheritance

Lesson 4.3a Chromosomes and genes

1 deoxyribonucleic acid (DNA)

2 double helix

3 the entire genetic material of an organism

4 They are distributed across the chromosomes.

5 two – one inherited from each parent

6 A gene is a short section of DNA on a chromosome.

7 4

8 The proteins are coded for by the sequence of bases in the DNA molecule.

Lesson 4.3b Sex determination in humans

1 Genetic material comes from both parents, producing variation. Offspring are different from each other, and their parents. If the environment changes, because of their genetic differences, some offspring are more likely to survive than others.

2 The parents produce sex cells, or gametes, by meiosis.

3 When the cells divide to produce gametes, the chromosomes line up and swap genetic information.

4 Fertilisation is random.

Lesson 4.3c Single gene inheritance

1 A dominant allele is always expressed, even if only one copy is present.

2 A recessive allele is only expressed if two copies are present (no dominant allele is present).

3 BB

4 B

5

		Mother (tt) gametes	
		t	t
Father (Tt) gametes	T	Tt	Tt
	t	tt	tt

6

		Female parrot (Bb) gametes	
		B	b
Male parrot (Bb) gametes	B	BB	Bb
	b	Bb	bb

Lesson 4.3d Genotype and phenotype

1 The alleles present for a particular gene make up the organism's genotype. All the genes present in an individual organism develop its observable appearance and character. These characteristics are its phenotype.

2 The phenotype for someone with a Bb genotype would be a carrier for red–green colour blindness.

3 Human height is determined by many genes, each with different alleles. The phenotype of these characteristics result in continuous variation with an unlimited number of possible values.

4 the colour of human skin, hair and eyes

5 Identical twins have the same genotype, but differ in their phenotype. So it is possible to determine the contribution of genotype to a particular trait by studying identical twins.

6 Blood type, eye colour, hair colour and IQ are all influenced by genes, but there is a higher percentage of correlation in identical twins than in fraternal twins.

End of chapter questions

1 B genome [1 Mark]

2 C meiosis [1 Mark]

3 Alleles for a particular characteristic are located at identical positions on each chromosome of the chromosome pair. [1 Mark] The structure of DNA is like a twisted ladder. The shape of this molecule is described as a double helix. [1 Mark]

4 Genes are regions of DNA that carry the code to control a particular cell activity. Different genes control the development of different characteristics of an organism. Different genes are inherited from each parent as dominant or recessive alleles, which determine which of the genes are expressed. [2 Marks]

5a Dominant TT [2 Marks]

5b Tt and tt [1 Mark]

5c Tt able to roll tongue; tt not able to roll tongue [1 Mark]

6 C variation [1 Mark]

7 Egg and sperm cells (gametes) are produced during meiosis (reduction division). Each gamete contains one of the two sex chromosomes – from chromosome pair 23. These carry the genes for sex determination. Female humans have two X-shaped chromosomes (XX). Males have an X- and a Y-shaped chromosome (XY). All the eggs produced by the mother contain X-chromosomes. Half of the father's sperm contain the X-chromosome and half the Y-chromosome. Therefore, a child will always inherit an X chromosome from their mother but they can receive either an X- or a Y-chromosome from their father. Students' own diagrams, based on Figure 4.3.6 on page 333 of the Student Book [2 Marks]

8 Students' own diagrams, with X circled for egg cell and X or Y circled for sperm [2 Marks]

9a

		Female (Bb) gametes	
		B	b
Male (Bb) gametes	B	BB	Bb
	b	Bb	bb

[2 Marks]

9b 25% [1 Mark]

10 Single gene inheritance: cystic fibrosis, ability to taste PTC, tongue rolling to U shape, red–green colour blindness, any other suitable answer.

Polygenic inheritance: human height, human skin, hair and eye colour, or any other suitable answer. [2 Marks]

11 Students' own diagrams, based on diagram given but with one each of the solid and dotted chromosomes added to each blank circle [2 Marks]

12 XX 2 girls, XY 1 boy [1 Mark]

13 C 50% [1 Mark]

14

		Mother (Cc) gametes	
		C	c
Father (Cc) gametes	C	CC	Cc
	C	Cc	cc

25% probability that the child will have cystic fibrosis. [6 Marks]

15 heterozygous: two alleles of different types, e.g. Bb

homozygous: two alleles of the same type, e.g. BB or bb
phenotype: observable appearance and characteristics based on the genes
genotype: the alleles present for a particular genetic make-up
For example, the phenotype for someone with a bb genotype would be red–green colour blindness.
Dominant: an allele that is always expressed, even if only one copy is present, e.g. TT or Tt
recessive: an allele that is only expressed if two copies are present, e.g. tt
Or any suitable examples. [3 Marks]

16 12 600 ÷ 14 000 = 90%; in a town with 20 000 population the number with blue eyes would be 20 000 × 0.9 = 18 000. [2 Marks]

17a

		Mother (Bb) gametes	
		B	b
Father (bb) gametes	b	Bb	bb
	b	Bb	bb

[2 Marks]

17b

		Mother (Bb) gametes	
		B	b
Father (Bb) gametes	B	BB	Bb
	b	Bb	bb

[2 Marks]

17c for a, 50%; for b, 25% [1 Mark]

[Total: 40 Marks]

Chapter 4.4 Variation and evolution

Lesson 4.4a Mutations

1 a change to the DNA, as the result of chemicals or radiation, or spontaneously

2 Some mutations can make individuals more likely to survive and reproduce, e.g. the dark form of the peppered moth on tree trunks covered in soot.

3 If it occurred in a stretch of DNA that is a functional gene.

4 Because we have two copies of each gene, it's likely that, if one is faulty, the other will be normal and so the protein can be produced as usual. There are also instances where a change in the sequence of bases may not lead to a change in the function of a protein.

5 Most mutations have no effect on the phenotype of an organism.

6 Mutations in a gene code can cause a change in DNA sequence and possibly in the amino acid sequence. If a different amino acid, or no amino acid, is produced, this can lead to a change in the phenotype.

Lesson 4.4b Evolution through natural selection

1 The Galápagos Islands are 600 miles off the coast of South America and arose by volcanic action.

2 Some species on the islands were similar to those on the mainland, but not the same. Others were very different. The giant tortoises were all different from island to island. Darwin also noted three species of mockingbird, each living on a different island. He realised that species were not fixed: they can change. Because of variation in a species, some individuals survived better than others.

3 a group of organisms that can interbreed successfully and produce fertile offspring

4 Mules are infertile because of their odd (rather than even) number of chromosomes (63).

5 competition among the birds for different food supplies

6 Slight variations in beak shape enabled some birds to exploit slightly different food supplies, e.g. small seeds, nuts, cacti and insects. Birds also selected different habitats in which to live, in order to survive. There are now 13 species of finch living on the Islands.

Lesson 4.4c Evidence for evolution from fossils

1 Depending in the rock layer in which they are found. Older fossils in older deeper rock

sediments, in succession to fossils in the most recent rock sediments.

2 Many early forms of life were microorganisms or were soft-bodied and left few traces behind.

3 From an animal the size of a small dog, called *Hyracotherium*, which had toes to larger animals in which toes have been lost during evolution and hooves developed.

4 The older fossils have not changed much compared with younger fossils and species today.

5 In a population of bacteria exposed to the antibiotic, some are resistant because of mutations; bacteria with the resistant genes survive and pass these on to offspring as they divide; eventually, the whole population becomes resistant to the antibiotic.

6 Owing to genetic variation, some bacteria are better able to survive in the changed environment; antibiotic resistance spreads throughout the population. *Note that new species of bacteria are not produced, simply resistant strains.*

Lesson 4.4d Identification and classification of living things

1 Carl Linnaeus

2 the binomial system

3 It allows scientists to identify, group and properly name organisms via a standardised system.

4 He grouped specimens hierarchically, into kingdoms, classes, orders, genera and species. He standardised naming by giving a unique Latin name to each individual species.

5 Modern models rely on comparing the DNA of different species. Early models grouped species by appearance.

Lesson 4.4e Selective breeding

1 wool production, milk production

2 Animals in a population show genetic variation. Humans selected those individuals with the characteristics that they required and allowed them to breed to produce offspring, some of which also had the desired characteristic. This was repeated over many generations.

3 three from: grow and mature quickly, have a distinctive taste, aroma or colour, have long shelf life, store well or can be frozen, yield, quality, disease resistance, drought resistance

4 The whole crop could be lost because it would be genetically uniform and unable to adapt to the new conditions.

5 Unfavourable traits could be amplified in the population.

6 Any example to explain inbreeding, such as 'The inbreeding of dogs for show has led to hip, heart and eye problems in some animals.'

Lesson 4.4f Genetic engineering

1 a DNA molecule that is used to artificially carry foreign genes from one cell to another

2 Bacteria contain small DNA molecules called plasmids that can be used as vectors. Bacteria act as host organisms and grow rapidly.

3 resistance to disease, increased yields

4 fungi, viruses

5 the deliberate modification of the characteristics of an organism by manipulating its genetic material

6 bacteria, yeasts

Lesson 4.4g Gene technology: benefits and risks

1 GM crops have increased yields and will grow in poor soil and harsh environments so can be accessed by all people at all times to produce enough food for an active, healthy life.

2 The number of hectares dedicated to growing herbicide-tolerant, insecticide-resistant and both herbicide-tolerant and insect-resistant crops has increased from 1996 to 2012. The area for herbicide-tolerant crops has increased the most. The area of crops that are both herbicide tolerant and insect resistant has increased more since 2004, which may mean that the plants have crossed to select both genes.

3 that they may damage the environment as pollen could be toxic to other insects that are essential pollinators of crops and other plants **or** transfer their antibiotic-resistant genes to soil microorganisms, causing a general increase in the level of antibiotic resistance in the environment

4 Students' own answers with opinions and suitable justifications.

5 moral obligation to achieve global food security by growing GM organisms; should not use public money to fund GM; other suitable answers

Lesson 4.4h Maths skills: Using charts and graphs to display data

1 Students' own bar charts, based on the data in the table on page 358 of the Student Book

2 25%

3 Students' own bar charts, based on the data in the table at the top of page 359 of the Student Book

4 Students' own histograms, based on the data in the table at the bottom of page 359 of the Student Book

5 Students' own histograms, based on their own data for height of students in their science class

End of chapter questions

1 Charles Darwin [1 Mark]

2 because most of the early species were microorganisms or had soft bodies and fossils were not formed [2 Marks]

3 Some archaea and bacteria have left traces of the unique chemicals they produced. There is now clear evidence going back 3.5 billion years. [1 Mark]

4 the offspring of two plants or animals of different species or varieties [1 Mark]

5 the product of meiosis, mutations and sexual reproduction, which all lead to changes in the genome [1 Mark]

6 Students' own bar charts, based on the data in question 6 on page 362 of the Student Book [1 Mark]

7 40% [1 Mark]

8 They become separated and isolated from each other, so that eventually they stop being able to interbreed to produce fertile offspring. [3 Marks]

9 the process in which organisms that are better adapted to their environment tend to survive and produce more offspring, leading to evolution [2 Marks]

10a Students' own graphs, based on the data in question 10 on page 362 of the Student Book [4 Marks]

10b The smoke concentration decreases from 1960 to 1975. Dark coloured ladybirds are more easily seen by predators and are therefore not at a selective advantage. Numbers stabilise at around 10%. The plateau for ladybirds lags about 5 years behind the decrease in smoke concentration. The number of lighter coloured lady birds may increase, as they are at a selective advantage. [2 Marks]

11 DNA is extracted from pancreas cells. An enzyme is used to isolate the gene that codes for insulin production. A plasmid from a bacterial cell is cut open using the same enzyme. The insulin gene is inserted into the plasmid. The plasmid is put back into the bacterial cell. The genetically modified bacteria are cultured and grown in fermenters and then the product is removed and processed into human insulin. [2 Marks]

12 any two from: manipulating animals for human ends, inserting genes from one organism into another species; tampering with something made by God; health risks to humans; risks of environmental contamination by GM crops [2 Marks]

13 Grow wheat varieties under drought conditions, take seed from the plant that best survives and repeat the process. Insert genes from plants that are drought resistant into

wheat varieties. Test varieties for drought resistance. [6 Marks]

14 Finches on the Galápagos Islands:13 species of finch living on the Islands with slight variations in beak shape enabled some birds to exploit slightly different food supplies, for example, small seeds, nuts, cacti and insects. Fossil records of species such as horses showing change with time. Or any suitable answer. [2 Marks]

15 a histogram, which is more suitable because it compares variables; students' own histograms based on the data in the table in question 15 on page 363 in the Student Book
Data show there is a range of bone densities; most people have densities between 141–160 g/cm^2. [4 Marks]

16a D and E [1 Mark]

16b Both B and C diverged together initially before diverging from each other. A diverged separately before B and C diverged. [2 Marks]

16c Compare the DNA of the species and look for similarity and variation. [1 Mark]

[Total: 40 Marks]