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Chapter 1

1 **a)** Diagram should show each part of a plant cell and its function, e.g. cell wall (maintains shape of cell), cell membrane (controls entry and exit of substances), cytoplasm (where metabolism/reactions take place), vacuole (stores dissolved substances), nucleus (controls activities of cell), chloroplasts (photosynthesis), mitochondria (respiration).

b) An animal cell lacks a cell wall, a large permanent vacuole and chloroplasts.

2 Description, in words or diagrams, should include the following points:

- enzymes are biological catalysts
- they speed up reactions in cells without being used up
- each enzyme catalyses a different reaction
- the production of enzymes is controlled by genes
- enzymes are made of protein
- the substrate attaches to the enzyme at the active site
- the substrate fits into the active site like a key in a lock
- this allows the products to be formed more easily
- intracellular enzymes catalyse reactions inside cells
- extracellular enzymes are secreted out of cells (e.g. digestive enzymes)
- they are affected by changes in pH and temperature.

3 **a)** About 75 °C.

b) At 60 °C the molecules of enzyme and substrate have more kinetic energy and move around more quickly. There are more frequent collisions between enzyme and substrate molecules, so more reactions are likely to take place.

c) The microorganism lives at high temperatures, so it needs 'heat-resistant' enzymes with a high optimum temperature.

d) It is denatured.

4 Diffusion is the net movement of particles (molecules or ions) from a high to low concentration. It does not need energy from respiration. Active transport uses energy from respiration to transport particles against a concentration gradient.

5 The function of the motor neurone is to send nerve impulses to muscles and glands. It has a long axon which conducts these impulses. It has a cell body with many extensions called dendrons and dendrites, which link with other neurones at synapses. At the other end of the neurone, the axon branches and forms connections with muscle fibres, called nerve–muscle junctions.

The palisade cell's function is photosynthesis. Palisade cells are near the top surface of the leaf, where they are close to the sunlight. They have thin cell walls, so the light can easily reach the many chloroplasts that the cell contains.

6 **a)** They carry out most of the reactions of respiration in the cell, providing it with energy.

b) Active transport. This uses the energy from the mitochondria.

c) Diffusion. The removal of glucose at A lowers the concentration inside the cell, so that the concentration at B is higher than inside the cell. Therefore glucose can diffuse down a concentration gradient.

d) Increases the surface area for greater absorption.

Chapter 2

1 **a)** i) Fungi

ii) Protoctists

iii) Plants

iv) Bacteria

b) Like most protoctists, *Euglena* is a microscopic, single-celled organism. It has features of both plant and animal cells: like plants, it contains chloroplasts; like animals, it can move.

2 **a)** Diagram should show a core of DNA or RNA surrounded by a protein coat. (It may also have an outer envelope or membrane derived from the host cell.)

b) A virus can be considered either as living or as a chemical. It does not have any of the normal characteristics of living things, except that it is able to reproduce.

c) Viruses can reproduce only inside a host cell, by taking over the cell's genetic machinery to make more virus particles. So viruses are all parasites.

3 **a)** An animal that does not have a vertebral column (backbone).

b) Fine, thread-like filaments forming the feeding network of cells of a fungus.

c) A type of nutrition used by most fungi and some bacteria, where the organism feeds on dead organic material by digesting it using extracellular enzymes.

End of Section A Questions

1 **a)** i) nucleus, mitochondrion (both needed for 1)

ii) nucleus, chloroplast, mitochondrion (all needed for 1)

iii) nucleus, mitochondrion (both needed for 1).

b) The cells in a root have no chloroplasts because they don't receive any light and so can't carry out photosynthesis (1).

c) Nucleus controls the activities of the cell (1); chloroplast absorbs light energy for photosynthesis (1); mitochondrion carries out some reactions of respiration to release energy (1).

2 **a)** The artery is an organ because it is made of several tissues; the capillary is made up of only one type of cell.

b) i) Breaks down large insoluble molecules (1) into smaller soluble molecules that can be absorbed (1).

ii) (1 mark for organ, 1 mark for function).

Three from:

- mouth: chews / breaks down food into smaller pieces / produces saliva;
- oesophagus (gullet): move food from mouth to stomach;
- stomach: produces digestive enzymes;
- pancreas: produces digestive enzymes;
- liver: makes bile;
- ileum (small intestine) produces digestive enzymes / absorbs products of digestion;
- colon (large intestine): absorbs excess water;
- rectum: stores waste (faeces).

iii) (1 mark for system, 2 marks for organs).

Two from:
- Breathing system: trachea, lung, diaphragm;
- Circulatory system: artery, vein, heart;
- Musculoskeletal system: muscle, joint, (named) bone;
- Nervous system: brain, spinal cord;
- Reproductive system: testis, ovary, uterus, penis;
- Excretory system: kidney, bladder.

3 a) i) 4 g (1). Mass at start was 100 g, decreased to 96 g due to oxygen lost (1).

ii) Half this mass = 2 g (1). This loss in mass occurs by (approximately) 0.5 minutes / 30 seconds (1).

iii) At the start there are a lot of enzyme and substrate molecules, so there are a lot of successful collisions (1). As the reaction proceeds, the number of substrate molecules decreases, so there are fewer successful collisions (1).

b) i) There would be no difference / 4 g formed (1); because the temperature affects only the reaction rate, not the end point (1).

ii) The time would be shorter (1) because the rate of reaction is speeded up by the increase in temperature (1).

4 a) 1 mark for each correct box.

Feature	Active transport	Osmosis	Diffusion
particles must have kinetic energy	✗	✓	✓
requires energy from respiration	✓	✗	✗
particles move down a concentration gradient	✗	✓	✓
process needs special carriers in the membrane	✓	✗	✗

b) i) (As the temperature rises) ions gain kinetic energy (1), so they move faster (1).

ii) Above this temperature the cell membranes are being denatured (1) so are more permeable to ions (1).

5 a) i) So that each of the two cells produced (1) will have the correct number of chromosomes / correct amount of DNA after the division (1).

ii) The nucleus has divided into two (1).

b) i) They increase the surface area for absorption (1).

ii) They (further) increase the surface area for absorption (1).

iii) As the glucose moves out of the cell, the concentration inside the cell decreases (1) and increases the concentration gradient for diffusion of glucose into the cell (1).

6 a) i) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO^2 + 6H^2O$ (1 for each correct part).

ii) It is the same (1), because there are six molecules of each / same number of molecules / same number of moles (1), 1 mole of any gas has the same volume (1).

iii) Any sensible experimental error stated (1) with brief explanation (1).

iv) No oxygen would be used up (1), so distance moved would be less (1).

7 (1 mark for each row)

Feature	Type of organism		
	Plant	Fungus	Virus
They are all parasites	✗	✗	✓
They are made up of a mycelium of hyphae	✗	✓	✗
They can reproduce only inside living cells	✗	✗	✓
They feed by extracellular digestion by enzymes	✗	✓	✗
They store carbohydrates as starch	✓	✗	✗

8 Plants have cell walls made of cellulose. They store carbohydrate as the insoluble compound called starch or sometimes as the sugar sucrose. Plants make these substances as a result of the process called photosynthesis. Animals, on the other hand, store carbohydrate as the compound glycogen. Both animals' and plants' cells have nuclei, but the cells of bacteria lack a true nucleus, having their DNA in a circular chromosome They sometimes also contain small rings of DNA called plasmids, which are used in genetic engineering. Bacteria and fungi break down organic matter in the soil. They are known as decomposers / saprotrophs. Some bacteria are pathogens, which means that they cause disease. (8)

Chapter 3

1

	Action during inhalation	Action during exhalation
External intercostal muscles	(contract)	relax
Internal intercostal muscles	relax	contract
Ribs	move up and out	(move down and in)
Diaphragm	contracts and flattens	relaxes and becomes dome-shaped
Volume of thorax	increases	decreases
Pressure in thorax	decreases	increases
Volume of air in lungs	increases	decreases

2 When we breathe in, the external intercostal muscles between our ribs contract, pulling the ribs up and out. The diaphragm muscles contract, flattening the diaphragm. This increases the volume in the chest cavity, lowering the pressure there, and causing air to enter from outside the body, through the nose or mouth. This is called ventilation. In the air sacs of the lungs, oxygen enters the blood. The blood then takes the oxygen around the body, where it is used by the cells. The blood returns to the lungs, where carbon dioxide leaves the blood and enters the air sacs. When we breathe out, the external intercostal muscles relax and the ribs move down and in. The diaphragm muscles relax, and the diaphragm returns to a dome shape. These changes decrease the volume of the chest cavity, increasing the pressure in the cavity, pushing the air out of the lungs.

3 **a)** When the volume of the chest is increased by the movements of the ribs and diaphragm, the drop in pressure in the chest cavity draws air into the pleural cavity through the puncture in the chest wall, instead of through the mouth or nose into the lung.

b) Each lung is isolated from the other by being in a separate pleural cavity, so a pneumothorax on one side will not affect the opposite lung.

c) A tube is inserted through the chest wall into the pleural cavity on the side of the injured lung. This stops ventilation in that lung, while the other lung will be ventilated normally.

4 **a)** The rings support the trachea so that it does not collapse during inhalation.

The gap in the 'C' allows food to pass down the oesophagus, which runs next to the trachea, without catching on the rings.

b) The short distance allows easy diffusion of oxygen into the blood, and diffusion of carbon dioxide out of the blood.

c) The mucus traps bacteria and dirt particles. The cilia beat backwards and forwards to sweep these towards the mouth, preventing them entering the lungs.

d) Smoke contains carbon monoxide, which displaces oxygen from the haemoglobin of the red blood cells of the smoker.

e) The addictive drug in tobacco smoke is nicotine. Smokers who are trying to give up can use patches or gum to provide the nicotine they normally get from cigarettes, reducing the craving to smoke.

f) The large surface area is provided by the alveoli. It allows for efficient diffusion of oxygen into the large blood supply, and efficient removal of the waste product, carbon dioxide.

5 Bronchitis is a lung disease caused by irritation of the linings of the airways to the lungs, and may be made worse by bacteria infecting the bronchial system.

Emphysema is a lung disease where the walls of the alveoli break down and then fuse together, reducing their surface area. (Both diseases may be caused by smoking.)

6 **a)** Some points are:
- non-smokers have a low death rate from lung cancer at all ages
- the death rate from lung cancer among smokers increases with age
- the death rate increases with the number of cigarettes smoked per day.

(Numbers should be used from the graph to illustrate any of these points.)

b) For 55-year-olds smoking 25 a day: about 4.5 per 1000 men (or 45 per 10 000 men).
For 55-year-olds smoking 10 a day: about 1 per 1000 men.

c) Probably this investigation. The graph shows a direct relationship between number of cigarettes smoked and incidence of lung cancer, in one particular type of person (middle-aged male doctors): in other words, a more controlled group. In Table 3.2 the patients were matched for age, sex etc. but were from a more varied background. There could be other reasons for the correlation that had not been considered. However, they both show a strong link.

7 The leaflet should not be too complicated or have too much information so that it puts the reader off. It must have a clear message.

Chapter 4

1 **a)** Starch: take a sample of the water in a spotting tile and add a drop of iodine solution. The colour changes from orange to blue-black.

Glucose: take a sample of the water in a test tube and add blue Benedict's solution. Place the tube in a water bath and heat until it boils. A brick-red precipitate results.

b) The starch molecules are too large to pass through the holes in the Visking tubing. Glucose molecules are smaller, so they can pass through.

c) The blood.

d) Large, insoluble food molecules are broken down into small, soluble ones.

2 **a)** It is body temperature.

b) It had been broken down into smaller molecules called peptides (short chains of amino acids) forming the clear solution.

c) The enzyme pepsin does not work in alkaline conditions, it is denatured.

d) The experiment is looking at the effects of pepsin on the egg white. The control is carried out without the enzyme; all other factors are the same. This shows that it is the enzyme that breaks down the protein. In other words, the egg white does not break down by itself.

e) The enzyme works more slowly at a lower temperature. There are fewer collisions between enzyme and substrate molecules, because they have less kinetic energy.

f) Hydrochloric acid kills bacteria in the food entering the stomach.

g) By alkaline secretions in the bile and pancreatic juice.

3

Enzyme	Food on which it acts	Products
(amylase)	starch	maltose
(trypsin)	protein	peptides
lipase	fats	(fatty acids and glycerol)

4 Descriptions of any four of the following:
- length, which increases time and surface area for absorption
- folds in lining, which increase surface area
- villi covering lining, which increase surface area
- microvilli on lining cells, which increase surface area
- capillary networks in villi, where products are absorbed
- lacteals in villi, which absorb fats.

5 The account should include full descriptions of most of the following points:
- digestion of starch to maltose in the mouth, action of saliva in moistening food
- mechanical digestion by the teeth
- movement through the gut by peristalsis (diagram useful)
- digestion of protein by pepsin in the stomach and the role of hydrochloric acid
- emulsifying action of bile from the liver on fats
- pancreatic enzymes (amylase, trypsin, lipase) and their role in digestion of starch, protein and fats
- adaptations of the ileum for the absorption of digested food (see question 4)
- role of the colon in absorption of water.

6 a) Energy = (20 × 18 × 4.2) = 1512 joules = 1.512 kilojoules.

b) Energy per gram = 1.512 ÷ 0.22 = 6.872 kJ/g.

c) There are several errors involved. Some major ones include:
- some of the energy from the burning pasta is used to heat the test tube, thermometer, etc.
- much energy will be lost when heating up the air near the tube, or when transferring the pasta
- not all the energy in the pasta will be released when it burns
- some energy will be lost when evaporating the water from the tube
- measurement errors such as measurement of the volume of water and temperatures (although these are probably small compared with the other reasons).

d) One way is to shield the tube inside (for example) a metal can, to reduce heat losses to the air (or use a calorimeter).

e) Peanuts contain a large proportion of fat, which has a high energy content. Pasta is largely carbohydrate, which contains less energy per gram.

Chapter 5

1 **a)** Single: fish; double: human or other named mammal.

b) i) The blood passes once through the heart in a single, and twice through the heart in a double system for every complete circulation of the body.

ii) Double circulatory system pumps the blood twice per circulation so higher pressures can be maintained and blood travels more quickly to the organs.

c) Diffusion can take place because it has a large surface area compared with its volume.

2 **a)** A red blood cell has a large surface area compared with its volume; contains haemoglobin; and has no nucleus, so more space is available for haemoglobin.

b) i) Oxygen dissolves in the liquid lining the alveoli and then diffuses down a concentration gradient through the walls of the alveoli and capillaries into the plasma and into the red blood cells.

ii) Oxygen dissolves in the plasma and then diffuses down a concentration gradient through the walls of the capillaries into the muscle cells.

c) Dissolved in plasma.

3 **a)** Arteries have thick walls containing much muscle tissue and elastic fibres. These adaptations allow their walls to stretch and recoil under pressure.

b) Veins have valves, thin walls with little muscle, and a large lumen (arteries have none of these).

c) Capillaries have walls one cell thick to allow exchange of materials. They have a very small diameter to fit between cells.

4 **a)** A = left atrium, B = (atrioventricular) valves, C = left ventricle, D = aorta, E = right atrium.

b) To ensure blood keeps flowing in one direction / prevent backflow of blood.

c) i) A; ii) E

5 **a)** i) A (red blood cell), identified by its colour (red) and biconcave disc shape.

ii) B (lymphocyte), identified by its colour (white) and large nucleus (to produce antibodies quickly).

iii) C (phagocyte), identified by its colour (white), variable shape (shows it is flowing) and lobed nucleus.

b) Platelets – blood clotting.

6 **a)** C, heart rate is increasing so more blood can be pumped to muscles.

b) E, brief jump in heart rate.

c) A, lowest rate.

d) B, increases from minimum to steady rate.

7 **a)** i) Low rate (75 beats/minute) because body is at rest, need for oxygen is low.

ii) Rate increases because more blood carrying oxygen for respiration needs to be pumped to muscles.

iii) Rate decreases as need for oxygen is reduced / lactic acid produced during exercise is removed (repaying oxygen debt).

b) The shorter the recovery period, the fitter the person.

Chapter 6

1 **a)** Light from an object is still refracted on to the retina, mainly by the cornea.

b) The changes that take place in the lens to allow focusing on objects at different distances. After the operation there is no lens.

c) Nearby objects. These need greater refraction of the light, which will only be possible with the help of glasses.

2 **a)**

Function	Letter
refracts light rays	G
converts light into nerve impulses	A
contains pigment to stop internal reflection	B
contracts to change the shape of the lens	E
takes nerve impulses to the brain	D

b) i) H

ii) Contraction of circular muscles in the iris reduces the size of the pupil, letting less light into the eye. Contraction of radial muscles increases the size of the pupil, letting more light into the eye.

iii) To protect the eye from damage by bright light, and to allow vision in different light intensities.

3 **a)** i) Sensory neurone

ii) Relay neurone

iii) Motor neurone

b) The sensory neurone carries impulses from sensory receptors towards the central nervous system. The motor neurone carries impulses out from the CNS to effector organs (muscles and glands). The relay neurone links the other two types of neurone in the CNS.

c) X: white matter, Y: grey matter, Z: dorsal root ganglion.

d) Electrical impulses.

e) The gap between one neurone and another is called a synapse. An impulse arrives at the end of an axon and causes the release of a chemical called a neurotransmitter into the synapse. The neurotransmitter diffuses across the synapse and attaches to the membrane of the next neurone. This starts an impulse in the second nerve cell.

f) This reflex is present from birth. A conditioned reflex is learnt.

4 **a)** i) cerebellum

ii) medulla

iii) cerebrum (motor area)

b) i) The motor area of the cerebrum controlling the arm muscles.

ii) The sensory area of the cerebrum concerned with smell.

5 **a)** A wide variety of answers are possible, such as:
- dust in the eye – secretion of tears
- smell of food – secretion of saliva
- touching a pin – withdrawal of hand
- attack by a predator – increased heart rate
- object thrown at head – ducking.

b) Nature and role of receptor and effector correctly explained, e.g. for 'dust in the eye' above:

i) The receptors consist of touch receptors in the eye. They respond by generating nerve impulses (which eventually stimulate the tear glands).

ii) Tear glands are the effectors. They secrete tears, washing the irritant dust out of the eyes.

c) Dust enters the eye and stimulates a touch receptor in the surface of the eye. The receptor sends nerve impulses along sensory neurones to the CNS (brain). In the CNS, impulses pass from sensory neurones to motor neurones via relay neurones. Impulses pass out from the CNS to the tear glands via motor neurones. These impulses stimulate the tear glands to secrete tears.

Chapter 7

1 **a)** 'Hormones' are chemical messenger substances, carried in the blood. 'Secreted' refers to the process where a cell makes a chemical that passes to the outside of the cell. 'Glands' are organs that secrete chemicals, and 'endocrine' glands secrete their products into the blood.

b) A = insulin, B = adrenaline, C = testosterone, D = progesterone.

2 **a)** Glucose has been absorbed into the blood following a meal (lunch!).

b) The high concentration of glucose in the blood is detected by the pancreas, which secretes the hormone insulin into the blood. The insulin stimulates the removal of blood glucose into body cells and causes the cells of the liver to convert glucose into an insoluble storage carbohydrate called glycogen.

c) i) Untreated diabetes leads to weakness and loss of weight, and eventually coma and death.

ii) Use of coloured test strips to detect glucose in the urine, and direct measurement of blood glucose using test strips laced in a sensor.

iii) Controlling the amount of carbohydrate in the diet, and injections of insulin.

Chapter 8

1 **a)** Maintaining constant conditions in the internal environment of the body.

b) Removal of waste products from cell metabolism.

c) Filtration of different sized molecules under pressure (as in the Bowman's capsule).

d) Reabsorption of different amounts of different substances by the kidney tubule.

e) An animal (mammal or bird) that generates internal (metabolic) heat to keep its temperature constant.

2 **a)** X = glomerulus, Y = Bowman's capsule (or renal capsule), Z = loop of Henlé.

b) A = water, urea, protein, glucose, salt.
B = water, urea, glucose, salt.

C = water, urea, salt.
D = water, urea, salt.

3 Description should include:

- increase in blood concentration
- receptors in hypothalamus of brain stimulated
- pituitary gland releases more ADH
- ADH travels to kidney in the bloodstream
- ADH causes collecting ducts of tubules to become more permeable to water
- more water reabsorbed into blood
- blood becomes more dilute, its concentration returns to normal
- definition of negative feedback
- explanation of why this is negative feedback.

4 **a)** Before the water was drunk, the volume of urine collected was about 80 cm^3. After drinking the water, the volume increased, reaching a peak of about 320 cm^3 after 60 min. After this, the volume decreased, until it reached the volume produced before drinking the water at about 180 min.

b) At 60 minutes, the concentration of ADH in the blood was low. This made the collecting ducts of the kidney tubules less permeable to water, so less water was reabsorbed into the blood and more was excreted in the urine, forming a large volume of urine. By 120 minutes, the secretion of ADH had increased, causing the collecting ducts to become more permeable, so that more water was reabsorbed into the blood and less entered the urine.

c) The volume would be less. More water would be lost in sweating, so less would be in the blood for production of urine.

d) 150 cm^3 is produced in 30 minutes, which is $150 \div 30 = 5$ cm^3 per minute.

- The filtration rate is 125 cm^3 per minute.
- Therefore 120 cm^3 is reabsorbed per minute.
- So the percentage reabsorption is: $(120/125) \times 100 = 96\%$

5

Changes taking place	Hot environment	Cold environment
(sweating)	increased sweat production so that evaporation of more sweat removes more heat from the skin	decreased sweat production so that evaporation of less sweat removes less heat from the skin
(blood flow through capillary loops)	vasodilation increases blood flow through surface capillaries so that more heat is radiated from the skin	(vasoconstriction decreases blood flow through surface capillaries so that less heat is radiated from the skin)
(hairs in skin)	hairs lie flat due to relaxed muscles, trapping less air next to the skin	hairs are pulled erect by muscles, trapping a layer of insulating air next to the skin
(shivering)	no shivering occurs	shivering occurs; respiration in muscles generates heat
(metabolism)	metabolism slows down, e.g. in organs such as the liver, reducing heat production	metabolism speeds up, e.g. in organs such as the liver, generating heat

6 **a)** The average body temperature of birds is slightly higher than that of mammals. This is because they have a higher metabolic rate, needed for flight (note that the flightless birds have a lower body temperature).

b) No. For example, the temperature of the camel and of the polar bear is the same, despite their different habitats.

c) The fur traps air, providing insulation. The colour acts as camouflage (so they are not so easily seen by prey).

Chapter 9

1 **a)** A = placenta, B = umbilical cord, C = amnion, D = amniotic fluid, E = uterus (womb).

b) The placenta function is the transfer of oxygen and nutrients from the mother's blood to the blood of the embryo / fetus, and removal of waste products such as carbon dioxide and urea from the fetus to the mother.

c) Just before birth, contractions of the muscle of the uterus (E) causes the amnion to rupture, allowing the amniotic fluid (D) to escape. This is the 'breaking of the waters'.

d) During birth, the cervix (F) becomes fully dilated, and strong contractions of the muscles of the uterus (E) pushes the baby out.

2 **a)** Method B. the formation of a new individual (the bud) does not involve sex cells from sex organs (as shown in method A).

b) In asexual reproduction, all the cells of the new individual are produced by mitosis from one cell in the parent. When cells divide by mitosis, all the new cells are genetically identical to the parent cell, and to each other.

c) If *Hydra* is well adapted to its environment, and the environment is stable, asexual reproduction will produce offspring that are also well adapted. However, if the environment changes, they may not be well adapted and may die out. Sexual reproduction produces offspring that show variation, so some of the new *Hydra* may be better adapted to survive in the new conditions.

3 **a)** i) A ii) B

iii) D iv) A

b) i) oestrogen

ii) Approximately 29–30 days. This can be seen by counting the days from the start of the first menstruation (day 0) to the start of the next menstruation.

iii) Fertilisation is most likely to have taken place about 15 days after the day when the last menstruation started. The last menstruation started on about day 57, so fertilisation probably took place on about day 72. (Note – this is very approximate!). After day 72 there is no menstruation, the uterus lining becomes thicker.

iv) To prepare for implantation of the fertilised egg.

4 There is evidence for and against the involvement of pollutants in lowering of the sperm count, and indeed whether or not the count has become lower at all. A good account of the student's findings should be a balanced one, giving both sides of the argument. It should be illustrated with some graphs or tables of data.

5 **a)** A = oestrogen, B = progesterone.

b) Corpus luteum

c) To prepare for the implantation of a fertilised embryo.

d) 13

e) Progesterone maintains the thickened uterus lining and prevents menstruation, as well as preventing further ovulation by inhibiting release of FSH and LH.

i) Progesterone is secreted by the corpus luteum.

ii) Progesterone is secreted by the placenta.

End of Section B Questions

1 **a)** (1 mark for each row correct)

Gas	Inhaled air	Exhaled air
nitrogen	(78)	(79)
oxygen	21	16
carbon dioxide	0.04	4
other gases (mainly argon)	(1)	(1)

b) It increases in exhaled air (1) because carbon dioxide is produced in respiration (1).

c) Excretion is getting rid of a waste product (1); carbon dioxide is a waste product (1).

d) i) Short distance (1) allows rapid diffusion of oxygen and carbon dioxide (1).

ii) Blood brings carbon dioxide and takes away oxygen (1) maintaining a diffusion gradient (1).

iii) Increases the surface over which diffusion of oxygen and carbon dioxide can occur (2).

2 **a)** i) A = stomach (1) because it is an acidic pH (1). B = small intestine (1) because it is an alkaline pH (1).

ii) Protein (1).

b) i) Liver (1).

ii) Proteins (1).

iii) The microorganisms turn urea into protein, which is a source of nutrients for the cattle, so increases growth rate (1).

iv) The Bowman's capsule carries out ultrafiltration of the blood (1) allowing water and small solute molecules such as urea to pass through into the kidney tubule, but holding back blood cells and large molecules (1). The loop of Henlé is involved in concentrating the fluid in the tubule (1), so that urine with a high concentration of urea is produced at the end of the tubule (1).

3 **a)** A = pulmonary vein, B = aorta, C = right atrium, D = left ventricle, E = renal vein (5).

b) X (artery) has narrow lumen / muscular wall, Y (vein) has large lumen / little muscle (2).

c) i) Increases rate and volume of heartbeat (2).

ii) Two from: increases breathing rate, diverts blood away from intestine to muscles, converts glycogen to glucose in the liver, dilates pupils, causes body hair to stand on end, increases mental awareness, increases rate of metabolism (2).

d) Reflex action is automatic / involuntary (1), voluntary action is one a person chooses to carry out / is initiated by the brain (1).

e) Lactic acid produced in muscles during exercise needs to be oxidised / removed / oxygen debt needs oxygen (1), oxygen is supplied by increased breathing rate and increased heartbeat (1).

4 a) All chemical reactions taking place in cells can continue at a steady rate / metabolism doesn't slow down in cold conditions (1).

b) i) Arterioles: blood remains in core of body and doesn't lose heat. Sweat: no heat lost in evaporating the sweat. Shivering: increases heat production by respiration (2).

ii) They have a lot of muscle fibres in their walls (1).

c) i) Antidiuretic hormone / ADH (1).

ii) More water has been lost as sweat (1).

iii) As concentration of water in blood decreases (1) ADH is released from the hypothalamus (1) and causes reabsorption of more water in kidney tubules (1).

5 a) i) B; ii) C; iii) B; iv) D; v) A (5).

b) Pregnancy is most likely to result from sexual intercourse around the time of ovulation (1), i.e. in the middle of the menstrual cycle / around day 14 (1). If a couple avoid having sexual intercourse at this time, the woman is less likely to become pregnant (1).

6 a) B (1). Cell division has reduced the chromosome number (1) from 46 to 23 / to the number present in gametes (1).

b) The fertilised egg / zygote has 46 chromosomes (1). It divides by mitosis (1), so that all the cells of the body also have 46 chromosomes (1). In the sex organs, gametes are produced by meiosis (1), which halves the chromosome number to 23 (1). Fertilisation of an egg by a sperm restores the chromosome number to 46 (1).

b) Any three for 3 marks, from:

- mitosis involves one division, meiosis involves two
- mitosis forms two cells, meiosis forms four
- mitosis forms cells with the same chromosome number as the parent cell / diploid, meiosis forms cells with half the chromosome number of the parent cell / haploid
- mitosis forms body cells, meiosis forms sex cells / gametes
- mitosis forms cells that are genetically identical, meiosis forms cells showing genetic variation.

Chapter 10

1 **a)** Iodine solution, turns from yellow-orange to blue-black.

b) Only the green areas, not covered, would contain starch.

c) Photosynthesis needs light and chlorophyll. These are only available in green, uncovered areas.

d) A storage carbohydrate. It is insoluble, so can be stored in cells and has no osmotic effects.

2

Part of leaf	Function
(Palisade mesophyll layer)	Main site of photosynthesis
(Spongy mesophyll layer)	Gas exchange surface: uptake of CO_2 and release of O_2 during photosynthesis; some photosynthesis
(Stomata)	Pores which exchange gases (CO_2, O_2 and water vapour) with the atmosphere
(Xylem)	Transport of water and minerals
(Phloem)	Transport of products of photosynthesis

3 **a)** At 0200 hours (night) the grass respires, producing CO_2, but there is no photosynthesis. At 1200 hours (midday) photosynthesis in the grass exceeds respiration, so CO_2 is used up.

b) At 0400 hours: light intensity. At 1400 hours: the concentration of CO_2 in the air.

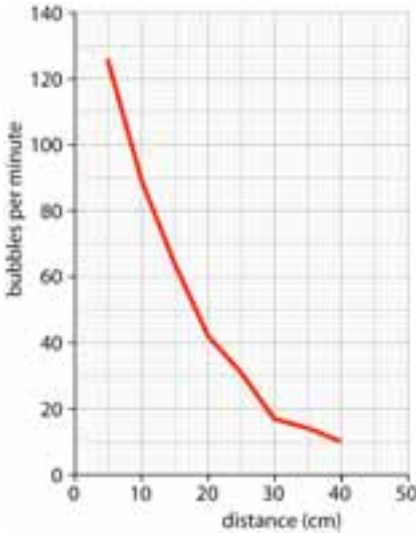
4

Substance	Use
(Glucose)	oxidised in respiration to give energy
(Sucrose)	main sugar transported in the phloem
(Starch)	storage carbohydrate
(Cellulose)	makes up plant cell walls
(Protein)	growth and repair of cells
(Lipid)	energy store in some plants, e.g. nuts, seeds. Part of all cell membranes.

5 **a)** The aeration tube supplies oxygen to allow the roots to respire. The foil stops light entering the tube, preventing the growth of algae.

b) Phosphate.

6 **a)**



b) About 52 bubbles per minute.

c)
- The gas is not pure oxygen, although it has a high oxygen content.
- The bubbles may not be all the same size.
- The water in the test tube may have increased in temperature as the lamp was brought nearer to the tube.

7 The account should include:
- description of photosynthesis as a chemical reaction where CO_2 and water are combined using light energy trapped by chlorophyll
- equation for the reaction
- leaf adaptations: details of palisade mesophyll, spongy mesophyll, stomata and epidermis, xylem and phloem (diagram needed)
- photosynthesis is needed at the start of food chains; how energy is harnessed by plants as the producers, and then passed to consumers.

Chapter 11

1 **a)** Loss in mass = (8.2 – 8.0) g = 0.2 g.
Percentage change = –0.2/8.2 × 100 = –2.4%.

b) Osmosis.

c) Solution A.

d) Solution C.

e) Solution B.

f) It is permeable to small molecules such as water, but not permeable to large molecules such as sucrose.

2 **a)** Long, thin extension of the cell has a large surface area for the absorption of water and minerals.

b) Dead, lignified cells with hollow lumen, forming long tubes that carry water and minerals throughout the plant. The lignified walls are tough so that they don't collapse under pressure.

c) 'Banana' shape with thicker cell wall on inside (around stoma) means that when the guard cells become turgid they change shape, bowing outwards, so opening the stoma for gas exchange.

3 a) If a ball of soil is not left around the roots (e.g. if they are pulled out roughly), it will damage the root hair cells on the roots. This will mean the plant will not be able to absorb water so easily, causing it to wilt.

b) If a cutting has too many leaves, it will lose too much water through transpiration and may wilt or die before it can establish new root growth.

c) When stomata are in sunken pits in the leaf, a region of humid air is trapped in the pit. This reduces evaporation through the stomata, conserving water in the plant.

d) Phloem contains products of photosynthesis, such as sugars, which provide food for the greenflies.

4 a) A = epidermis, B = phloem, C = xylem.

b) C. Xylem carries water up the stem. The dye is likely to be carried in this water.

5 a)

Condition	Curve
1	(B)
2	A
3	D
4	C

b) Humid air around the leaf reduces the diffusion gradient between the air spaces in the leaf and the atmosphere around the leaf. Moving air removes the water vapour that might remain near the stomata and slow down diffusion.

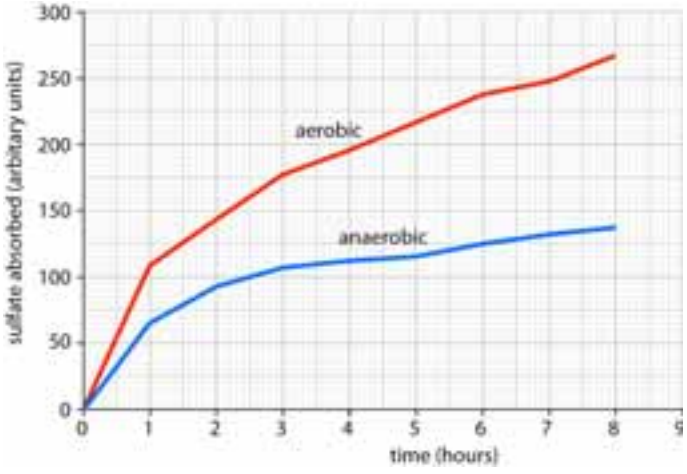
6 a) Water forms a thin layer around the cells of the spongy mesophyll of the leaf, then evaporates from this layer and exits through the stomata. The water potential of the mesophyll cells falls, so more water passes from the xylem to the cells by osmosis. A gradient of water potential is set up, from the xylem to the cells.

b) It would increase. A higher temperature would increase the rate of evaporation of water from the mesophyll.

c) Many examples possible, for example:

- cacti have leaves reduced to spines
- leaves rolled into a tube with most stomata facing the inside of the tube
- sunken stomata in pits
- hairy leaves to trap layer of moist air round stomata.

7 a)



b) Respiration (aerobic respiration).

c) Mineral ions such as sulfate are absorbed by active transport. This requires energy from respiration. Aerobic conditions provide the oxygen for aerobic respiration, which provides more energy than anaerobic energy; so more active transport can take place.

8 The description should include:

- uptake of water by osmosis from the soil through the root hairs
- the gradient of water potential across the root cortex, allowing water to move from cell to cell by osmosis
- passage of water into the xylem vessels in the root
- transport through the xylem to all parts of the plant
- evaporation of water vapour from the spongy mesophyll cells of the leaf, and loss through the stomata
- the water potential gradient in the mesophyll cells and water movement out of the xylem, the driving force for transpiration.

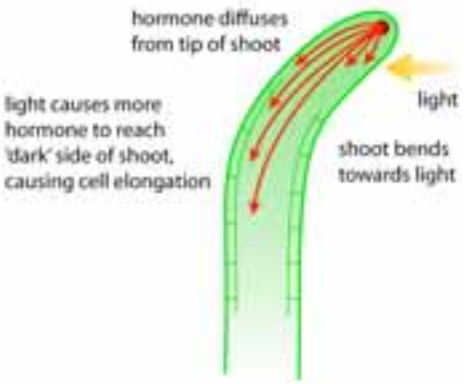
Chapter 12

1 **a)** i) The direction of light and the direction of gravity.

ii) The direction of gravity, and (in a few species) the direction of water.

b) The stem grows towards the light, which allows more photosynthesis, and growth of the plant.

2



3 **a)** The coleoptile would not bend towards the light. The movement of auxin on the left (dark) side would be interrupted by the mica sheet.

b) The coleoptile would grow (bend) towards the source of light. The greater amounts of auxin diffusing down the left side would be unaffected by the placement of the mica sheet. (It might even bend more than a control, with no sheet).

c) The coleoptile would grow (bend) towards the source of light. The mica would not interrupt the movement of auxin away from the light.

Chapter 13

1 **a)** Stigma.

b) By the coloured petals and nectaries / nectar.

c) Pollen tube should be shown growing down through the rest of the style and entering the ovary.

2 **a)** i) By wind. Some fruits (A, B and D) have hairs to act as parachutes. Others (C and E) are shaped like wings to catch the wind.

ii) By animals: e.g. fruits of bedstraw and cocklebur have hooks to catch in animal fur. By water: coconut fruits are dispersed by floating on the sea.

b) Dispersal avoids the new plants growing near the parent plants and competing for resources such as light, water or minerals.

c) The plants growing from seeds will be different from the parents, since they are produced by sexual reproduction, which introduces genetic variation.

3 **a)** This method of reproduction does not involve flowers / seeds / pollen and ovules, so is not sexual. It involves the tubers growing from body cells of the parent plant.

b) The tubers grow from body cells of the parent plant by mitosis, which produces cells that are genetically identical.

c) Growth may be affected by the environment of the plants, e.g. different soil minerals or different light intensity.

d) Sexual reproduction produces offspring that show variation, allowing them to survive if the environment changes.

4 **a)** A = stigma, B = ovary, C = anther, D = filament.

b) Any three of:
- lack of large petals (no need to attract insects)
- lack of brightly coloured petals (no need to attract insects)
- exposed stamens (to catch the wind and blow pollen away)
- exposed stigma (to catch windborne pollen)
- stigma feathery (to catch pollen).

c) The pollen grain grows a pollen tube, which digests its way through the tissue of the style and into the ovary. The pollen tube enters an opening in an ovule. The tip of the pollen tube breaks down and the pollen grain nucleus moves out of the pollen tube into the ovule, where it fertilises the nucleus of the egg cell (ovum).

d) Any four of:
- large petals
- brightly coloured petals
- stamens enclosed within flower
- stigma enclosed within flower
- stigma sticky
- nectaries present
- large, sticky pollen grains.

5 **a)** Method A. Fruits are produced by flowers via sexual reproduction, which introduces genetic variation.

b) Insect-pollinated. The flower has large, brightly coloured petals to attract insects.

c) The seeds pass through the animal's digestive system and are deposited with the animal's faeces, dispersing them away from the parent plant.

6 **a)** The banana plants reproduce asexually, so they are all genetically identical. Therefore all the plants are susceptible to the fungus, none is resistant to it.

b) If the plants reproduced sexually, this would introduce genetic variation. Some of the plants might then have resistance to the fungus, and would be able to survive.

c) Asexual reproduction is faster than sexual reproduction, so more banana plants can be produced more quickly. (Also, if the plants *are* resistant to a disease, they all will be, so won't be killed by it.)

End of Section C Questions

1 **a)** i) As light intensity increases, the rate of photosynthesis increases both at low and at high CO_2 concentrations (2). The rate of increase is faster at high CO_2 levels than at low CO_2 levels (1).

At low CO_2 concentration, the rate of photosynthesis reaches a plateau (1) below light intensity X (1). At high CO_2 concentration, the rate of photosynthesis reaches a plateau (1) at / after light intensity X (1).

Above light intensity X, the maximum rate of photosynthesis is faster / higher for high CO_2 concentration than for low CO_2 concentration (1).

ii) Up to X the limiting factor is light (1), because increasing light intensity increases the rate of photosynthesis (1). Beyond X the limiting factor is CO_2 (1), as increasing light intensity has no effect on the rate of photosynthesis (1) whereas increased CO_2 increases the rate (1).

b) i) Temperature, water availability.

ii) Reactions are slow at low temperatures (1), because the molecules have little kinetic energy (1) and therefore there are fewer successful collisions between enzyme molecules and substrates (1). Water is a raw material for photosynthesis (1).

c) 'Transducing' means changing one type of energy into another / light into chemical (1). The chemical energy is stored in the glucose / starch produced during photosynthesis (1).

2 **a)** i) To remove any water / sap on the outside of the cylinder (1).

ii) To allow an average to be calculated / to check reliability of results (1).

iii) So they all had the same surface area to volume ratio (1).

b) i) 3M sucrose has a lower water potential / lower concentration of water / higher concentration of solutes than potato cells (1), so water moves out of the cells and into the sucrose solution (1), resulting in a decrease in mass of the cylinder (1).

ii) (Approximately) 0.75 M (1), because there is no change in mass (1), as there is no net movement of water (1).

c) Repeat experiment with more cylinders (1), use more concentrations of sucrose between 0 and 1 M (such as 0.2 M, 0.4 M, etc.) (1).

3 **a)** i) A = Xylem (1) because it carries water to the leaf (1).
B = phloem (1) since it is the other vascular tissue in the vein, but is not carrying water (1).

ii) 1 = transpiration stream / under pressure / mass flow (1).
2 = osmosis (1).
3 = evaporation / diffusion (1).
4 = transpiration / evaporation (1).

b) Palisade layer cells contain many chloroplasts (1) which absorb light (1); spongy mesophyll cells contain chloroplasts (1) to absorb any light that has passed through the palisade layer (1).

c) Carbon dioxide enters through the stomata (1) but stomata need to be closed to prevent loss of water (1).

4 **a)** i) (Positive) phototropism (1).

ii) Any three from:

Auxin produced in tip of shoot (1) diffuses back down the shoot (1), auxin moves away from light source (1) causes growth on the dark side of the shoot (1).

iii) The plant receives more light for photosynthesis (1).

b) i) Any two from:

most curvature takes place at a wavelength of about 450 nm (1), light wavelengths above about 500–550 nm produce no curvature (1), there is a smaller increase in curvature with a peak at about 370 nm (1).

ii) Any two for two marks from:

the tip / something in the tip only absorbs these wavelengths of light (1), cannot absorb other wavelengths (1), these wavelengths are present in sunlight (1).

c) i) Gravity, water (2).

ii) Gravity: root grows towards gravity / positive geotropism (1), shoot grows away from gravity / shows negative geotropism (1).

Water: root (of some species) grows towards water / shows positive hydrotropism (1), shoot shows no response to water (1).

iii) Shoots grow upwards towards light needed for photosynthesis (1) and roots grow towards source of water (1).

5 **a)** i) B (1).

ii) F (1).

iii) E (1).

b) Any two for 2 marks:

- large petals
- brightly coloured petals
- stamens enclosed within flower
- stigma enclosed within flower.

c) i) H (1).

ii) G (1).

iii) C (1).

d) i) Pollination is the transfer of pollen from the anther to the stigma (1). Fertilisation is the fusion of the nucleus of the pollen grain with the nucleus of the ovum (1).

ii) Self-pollination means transfer of pollen from the anther of a plant to the stigma of the same plant (1). Cross-pollination is when pollen is transferred to the stigma of another plant (1).

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Chapter 14

1 **a)** Habitat: place where an organism lives; community: all the populations of living organisms in an ecosystem; environment: the non-biological components of an ecosystem; population: all the organisms of a particular species in an ecosystem.

b) Plants = producers; animals = consumers; decomposers = breakdown of dead material.

2 **a)** i) Plankton.

ii) Krill.

b) Quaternary consumer / top carnivore.

c) Very large amounts of photosynthesis / production by the plankton can support this number of trophic levels.

3 **a)** Any two from:

- trees → moths → small birds → owls
- trees → moths → small birds → weasels
- trees → moths → small birds → shrews
- trees → moths → beetles → shrews

b) Vole or small bird.

c) Reduction in dead leaves means there will be fewer earthworms and beetles, so less food for shrews.

d) In the pyramid of numbers there are only 200 trees, but each tree has a very large mass, and the pyramid of biomass shows the total mass of the trees.

4 **a)** X = ammonia; Y = nitrate; Z = decomposer.

b) Active transport.

c) Bacteria that convert nitrogen gas into ammonia.

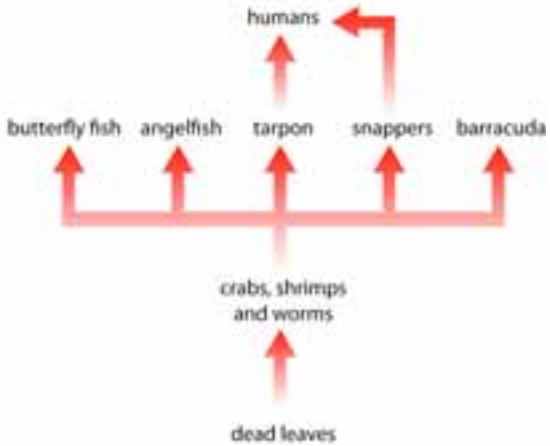
d) In urine / faeces and in death.

5 **a)** (125/3050) × 100 = 4.1%.

b) As urine / faeces, and as heat from metabolic processes / respiration.

c) Eaten by other herbivores, or ends up in dead matter / passes to decomposers.

6 **a)** (For simplicity, crabs, shrimps and worms can be put together. Arrows should point in the direction of energy flow.)



b) Any suitable food chain with four organisms, such as:
- dead leaves → crabs → tarpon → humans
- dead leaves → shrimps → snappers → humans

c) i) Carbon dioxide.

ii) Decomposers feed on the detritus; their respiration produces carbon dioxide as a waste product.

Chapter 15

1 Because of the massive increase in the human population.

2 **a)** The concentration of carbon dioxide is increasing.

b) The increase is due to increased burning of fossil fuels.

c) In the summer there is more photosynthesis, which lowers the concentration of carbon dioxide. In the winter there is less photosynthesis, so carbon dioxide levels increase.

3 **a)** Carbon dioxide, methane.

b) Without a greenhouse effect, the temperature on the Earth's surface would be much colder than it is now, and life would not be able to exist. (One estimate is that the average temperature would be 30 °C lower.)

c) Malaria is spread by mosquitoes, which are found in warmer regions of the world. If global warming occurs, mosquitoes will spread to more northerly parts of Europe.

4 Compare the amount of growth / number of the lichens at different distances from the source of the pollution. The more lichen plants, the less sulfur dioxide present.

5 **a)** Rain washes fertiliser into the pond, causing the algae to grow.

b) Rain washes the fertiliser down hill away from the pond.

c) Algae are photosynthetic protoctists. An increased temperature increases their rate of photosynthesis, so they grow faster.

6 Sewage causes growth of bacteria in the water. The bacteria need oxygen for growth, using up the oxygen in the water, so that the fish suffocate / die.

7 **a)** Pesticides kill pests (insects, mice, etc.) so less crop eaten; fertilisers supply minerals that increase the growth of crops.

b) Use manure as fertiliser. After the crop has been harvested, dig in remains of plants, allowing them to decay and release nutrients. Use crop rotation including leguminous plants to produce nitrates. Use biological control methods to reduce pests.

End of Section D Questions

1 **a)** i) Any of the following for 1 mark:
- plankton → sea butterfly → arrow worm → herring
- plankton → small crustaceans → large crustaceans → herring
- plankton → copepods → sand eel → herring

ii) Primary consumer = sea butterfly / small crustaceans / copepods (1 mark for correct organism from food chain used).

Secondary consumer = arrow worm / large crustaceans / sand eel (1 mark for correct organism from food chain used).

iii) Herring (1). It is a secondary consumer when it feeds on other small crustaceans, and a tertiary consumer when it feeds on sand eels or arrow worms (1).

b) i) Pyramid drawn correctly, with relative amounts of energy at each trophic level approximately correct (1).

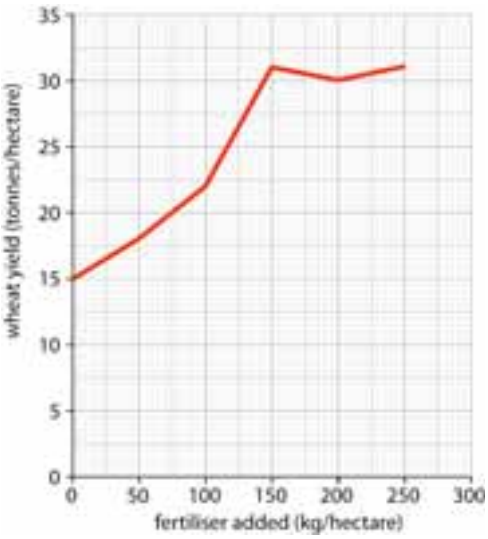
ii) (892/8869) × 100 = 10.1% (1 for correct values in calculation, 1 for answer).

iii) (91/892) × 100 = 10.2% (1 for correct values in calculation, 1 for answer).

iv) (8869/0.1) × 100 = 8 869 000 kJ (1 for correct values in calculation, 1 for answer).

v) Two from: losses from respiration / in movement / as faeces / undigested food (2).

2 a)



Axes correct way round, scales correct (1); axes labelled, with units (1); points plotted correctly (1); points joined with straight lines (1).

b) 30 kg/hectare (1). This amount gives maximum yield (1); any higher concentration would waste fertiliser / waste money (1) (since yield is not higher).

c) To make proteins (1).

d) Any of the following to a maximum of 5 marks:

- causes plants / algae to grow / form algal bloom
- reference to eutrophication
- plants /algae prevent light penetrating into the water
- submerged plants / algae underneath cannot photosynthesise so they die
- bacteria break down the dead plants / algae
- respiration of the bacteria uses up oxygen
- oxygen level of the water falls / water becomes anoxic
- aerobic animals / fish etc in the water die.

3 a) i) The insecticide becomes less effective / kills fewer insects over the three years (1). This is because some insects were resistant to the pesticide (1) so these reproduced / more resistant insects survived (1).

ii) Intermediate concentration (1), as almost as effective as the strongest concentration (1) and will be cheaper / less polluting (1).

b) i) When amounts of pesticide in body tissues build up over time (1).

ii) Named pesticide, e.g. DDT (1) accumulated in top carnivores / named example (e.g. osprey) (1) and caused death / other named problem (1).

iii) Could bioaccumulate in human tissues / cause illness / death (1).

4 a) Plants carry out photosynthesis (1), which converts carbon dioxide into organic carbon compounds (1).

b) Combustion of fossil fuels, which increases carbon dioxide levels (1). Deforestation, which increases carbon dioxide levels (1).

c) i) The bodies are broken down by respiration (1), which produces carbon dioxide (1).

ii) Insects chew bodies into smaller pieces (1), providing a larger surface area (1) for enzymes produced by decomposers (1).

iii) Award 4 marks for two sensible points from the curve, with reasons. e.g.

- curve 1 rises rapidly to a peak of CO_2 production by 7 days, whereas curve 2 shows little production during this time due to the slower action of decomposers on the intact bodies (2)
- curve 1 falls from the peak after 7 days due to material in the dead bodies being used up (1), while curve 2 shows little CO_2 production in this time (2)
- curve 2 starts to rise only at 9–12 days due to the slower action of decomposers on the intact bodies; CO_2 production in curve 1 has nearly fallen back to zero by 11 days (2).

5 a) 2 marks for examples of competition, e.g. for same food source / nest sites, etc. (animals), light / minerals / water (plants) (2). Less well adapted individuals die / best adapted survive (1) preventing population increasing / population numbers remain stable (1) (maximum 3 marks).

b) i) 2 marks for two from:

- mineral ions / named ion, for healthy growth
- light for photosynthesis
- water for photosynthesis / turgidity / transport.

ii) To kill the weeds before they produce seeds (1) reducing need to use more herbicide later in season (1).

c) i) Species A (1), because more beetles produced (1).

ii) The parasite kills species A (1) but does not affect numbers of species B (1). The first graph shows that species A is better at competing for resources than species B (1). The second graph shows that when species A is removed, species B can do better / increase in numbers (1).

6 a) (88 600 – 886)/88 600 × 100 = 99% (1 mark for calculation, 1 mark for answer; allow 1 mark if answer given is 1%).

b) Sulfur dioxide and nitrogen oxides are acidic gases (1). They are blown long distances by winds (1) and dissolve in rain (so acidifying ground water) (1). (Deduct 1 mark if carbon monoxide given as acidic gas.)

c) Dissolved / suspended solids make water cloudy / dirty (1), preventing light reaching plants (1), so plants are unable to photosynthesise (1) and therefore die (1).

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Answers

Chapter 16

1 **a)** A = base / adenine; B = base / cytosine; C = deoxyribose / sugar; D = phosphate; E = nucleotide.

b) Franklin used X-ray diffraction on DNA to find out about its structure. Watson & Crick used Franklin's data and other information to build a model of the structure of DNA.

c) A always pairs with T, and C always pairs with G.

2 **a)** i) A gene is a length of DNA that codes for a protein.

ii) Alleles are different forms of a gene.

b) A chromosome is a structure in the nucleus of a cell, composed of DNA (and proteins).

c) i) Both have 23 pairs of chromosomes in each cell.

ii) Woman's skin cells contain XX sex chromosomes, man's contain XY.

3 **a)** The two strands of the DNA separate; each strand acts as a template for the formation of a new strand; DNA polymerase assembles nucleotides into two new complementary strands.

b) i) Caused by an addition, duplication or deletion of a base, resulting in all triplets of bases after the mutation being different and so different amino acids are coded for.

ii) Caused by a change in one base in a triplet, by substitution or inversion, so that it codes for a different amino acid. Triplets after the mutation are not altered, so subsequent amino acids will not be affected.

4 **a)** A genetic disorder, caused by a chromosome mutation where three copies of chromosome 21 are present.

b) As the mother's age increases, the number of Down's syndrome babies increases, up to a maximum at about age 35, after which the number decreases.

c) The percentage of Down's syndrome babies continues to rise after age 35. The actual number falls only because older mothers have fewer babies.

Chapter 17

1 **a)** Both types of division start by each chromosome copying itself.

Plus any two of:

- mitosis produces two daughter cells, meiosis produces four daughter cells
- daughter cells from mitosis are genetically identical to each other and the parent cell; daughter cells from meiosis are genetically different from each other and the parent cell
- mitosis produces daughter cells with the same number of chromosomes as the parent cell / diploid to diploid; meiosis halves the chromosome number / diploid to haploid.

b) Mitosis, they are formed by division of body cells.

c) Because the number of chromosomes per cell is reduced by half.

2 **a)** They have been formed by mitosis, so are genetically identical.

b) Meiosis is used to form pollen and egg cells, so fertilisation results in seeds that are genetically different from each other.

3 **a)** Plants from cuttings would be genetically identical, which is better in order to make a fair comparison after the effects of the treatment with nitrogen-fixing bacteria. Seeds would be genetically different, so their growth might depend on their genes, rather than the treatment.

b) The nitrogen-fixing bacteria provide nitrates needed for growth. This is an environmental effect on growth, rather than a genetic one. Hence the environment plays a big part in the growth of these plants.

4 **a)** Meiosis, because sperm are gametes that are haploid / contain half the number of chromosomes of body cells.

b) Mitosis, because body cells are dividing to produce more body cells with the normal chromosome number.

c) Mitosis, because body cells are dividing to produce more body cells with the normal chromosome number.

d) Meiosis, because pollen grains are gametes that are haploid / contain half the number of chromosomes of the plant's body cells.

e) Mitosis, because the zygote must divide to produce more body cells with the normal chromosome number.

5 **a)** Genetic – eye colour is inherited and not affected by the environment.

b) Genetic – 50:50 chance of inheriting an X or a Y chromosome from their father.

c) Environmental – the pH of soil is a feature of the plant's environment.

d) Both – genes determine whether a plant falls into the tall or dwarf categories, but environmental factors affect how well each plant grows.

e) Both – genes affect the risk level, but environmental factors such as diet, smoking, etc. also have an effect.

6 **a)** Chromosomes align themselves along the equator of the cell, attached to the spindle fibres.

b) Spindle fibres shorten and pull chromatids towards opposite poles of the cell.

c) Chromosomes reach the opposite poles of the cell. Nucleus starts to re-form.

Chapter 18

1 **a)** All tall. **b)** 1 tall : 1 short (or 2 : 2).

c) All tall. **d)** 3 tall : 1 short.

e) 1 tall : 1 short (or 2 : 2). **f)** All short.

2 **a)** i) Homozygous.

ii) Dominant gene hides the expression of the recessive gene when heterozygous; recessive gene expressed only in homozygous form.

b) i) B and b; ii) all Bb.

c) i) Heterozygous.

ii)

	B	b
B	BB	Bb
b	Bb	bb

Phenotypes = 3 black : 1 red.

3 **a)** Gametes of parents = R and r
Genotypes of F1 = Rr
Genotypes of F1 parents = Rr and Rr
Gametes of F1 parents R, R and r, r
Genotypes of F2 =

	R	r
R	RR	Rr
r	Rr	rr

b) A, B and C are red, D is yellow.

4 **a)** Individual 8 has cystic fibrosis, but neither of his parents does, so they must be heterozygous and the allele must be recessive. If the allele were dominant, he would have to have inherited at least one dominant allele from one parent, so that parent would have cystic fibrosis too.

b) 3 and 4 must be heterozygous for the gene, as they do not have the disease, but their son does. 11 must be homozygous for the gene, since she has the disease.

c) i) Probability that the next child is male is 1 in 2, or 0.5:

	X	Y
X	XX	XY
X	XX	XY

ii) Let A = the normal allele of the gene and a = cystic fibrosis gene.
Individual 11's genotype = aa. Individual 10's genotype could be AA or Aa.
So there are two possible outcomes:
AA × aa

	A	A
a	Aa	Aa
a	Aa	Aa

Aa × aa

	A	a
a	Aa	aa
a	Aa	aa

Depending on whether 10 is AA or Aa, there could be no chance, or a 1 in 2 chance (0.5 probability) of their next child having cystic fibrosis. It could also be argued that if the genotype of 10 is unknown, the probability of the child having cystic fibrosis is 1 in 4, or 0.25.

5 a) Let S = allele for short hair and s = allele for long hair.

	S	s
S	SS	Ss
s	Ss	ss

There is a 1 in 4 chance of producing a long haired guinea pig (ss).

b) Breed the short-haired guinea pig with a homozygous long haired guinea pig (ss). If it is heterozygous (Ss), both long-haired and short-haired offspring will be produced (in a 1:1 ratio):

	S	s
s	Ss	ss
s	Ss	ss

If it is homozygous (SS), all offspring will have short hair:

	S	S
s	Ss	Ss
s	Ss	Ss

6 a) A gene is a length of DNA, coding for the production of a protein. Alleles are different forms of a gene. The phenotype is the appearance of an organism, or the features that are produced by a gene. (The way that a gene is 'expressed'.)

b) Let allele for red coat = R and allele for white coat = W (note that different letters are used, since this is a case of codominance).

i)

	R	R
W	RW	RW
W	RW	RW

ii)

	R	R
R	RR	RR
W	RW	RW

iii)

	R	W
R	RR	RW
W	RW	WW

c) Ratios in (b) are: i) all roan; ii) 1 red : 1 roan; iii) 1 red : 2 roan : 1 white.

Chapter 19

1 **a)** It means that the organisms which are best adapted to their environment are more likely to survive. They 'fit' their environment better.

b) Darwin and Wallace.

c) Any sensible answer, such as that the ideas were not understood, or that they clashed with the teachings of the church.

2 **a)** Because it was camouflaged against the dark sooty trees, and couldn't be seen easily by predatory birds.

b) Lichens were still growing on trees and so the darker moths could be seen easily by predatory birds.

c) Any sensible suggestion, such as: there is still interbreeding between light and dark forms of the moth, the environmental changes have been reversed in recent years, there has not been enough time for all of one form to be eliminated.

3 **a)** Rats with the resistant gene survived and reproduced, so now many more rats carry the gene. Rats without the gene did not survive to reproduce.

b) It would decrease as it would not give an advantage; rats that don't have the gene will breed equally well. (In fact rats with the warfarin gene have a selective disadvantage when warfarin is not being used, although students will not know this.)

4 **a)** They have a heavy beak, which is adapted to crush seeds.

b) They have a long, narrow beak, which can be used to probe under the bark of trees for insects.

c) Ancestors showed slight variations in their beaks. Where the variation enabled a bird to catch insects, or eat leaves and other food better than birds with other types of beak, the birds survived better (survival of the fittest) and reproduced, passing on their genes for the adaptation. Eventually groups of birds became so different from members of other groups that they couldn't interbreed, and formed new species.

5 The essay should include:

- evidence that evolution has taken place (geology, fossils, etc.)
- Darwin's observations and deductions
- meaning of 'survival of the fittest' and natural selection
- some examples of natural selection in action, such as the peppered moth, antibiotic resistance in bacteria, etc.
- how a new species is thought to evolve.

Chapter 20

1 **a)** Both involve selection of which animals or plants survive to breed.

b) In selective breeding the farmer / breeder does the selection. In natural selection it is the survival of the fittest in a habitat that leads to selection.

2 **a)**
- Plants have resistance to disease, so they are not killed by fungi, bacteria, etc.
- Plants are better suited to climate, so can grow well in a particular location.
- Plants have a better balance of nutrients; produce more nutritious food, or have a high vitamin content etc.

(Or any other correct reason.)

b) Two from: quicker to produce large numbers of plants because only a few cells needed; plants can be produced at any time of year since grown inside; large numbers of plants can be stored easily until needed.

c) All have same genes since produced by mitosis from cells of the same parent plant.

3 **a)** Milk yield and feed to milk conversion rate.

b) Choose a cow with the best characteristics and give hormone / FSH injections to cause multiple ovulations. Collect ova and use IVF to fertilise with sperm collected from a bull with the best characteristics. Separate cells of embryos that develop and produce large numbers of embryos. Screen for sex (males) and implant into surrogate mother cows.

4 **a)** Hybrid G was produced by selective breeding. Individual plants from pure lines of A and B were selected (for size of cobs) and crossed to produce hybrid E. Similarly, individual plants from pure lines of C and D were selected and crossed to produce hybrid F. Plants from hybrids E and F were then selected for their cob size, and crossed to produce hybrid G. (Crossing would be done by transfer of pollen from anthers to stigmas of plants.)

b) Cob G is larger, it has more seeds and the seeds are more even in size.

c) Any sensible suggestion, e.g. sequence the genes to show differences.

5 The essay should include:
- examples of traditional selective breeding of crop plants or domestic animals
- advantages of this type of artificial selection, e.g. to crop yield, characteristics of animals
- cloning of plants and its advantages
- cloning animals and its uses
- causes for concern with cloned organisms (e.g. cloned plants all genetically identical, so susceptible to same pathogens; cloned animals like ‘Dolly’ may have genetic defects; ethical issues).

End of Section E Questions

1 **a)** Toxic copper ions (1), only plants resistant to the ions will grow and reproduce; others will die (1).

b) Predation by lions (1), only those wildebeest that are fast runners (or equivalent) will survive and reproduce; others will be killed by lions.

c) Presence of pesticide (1), only those pests resistant to the pesticide will grow and reproduce; others will die (1).

2 **a)** Tips of stems and side shoots removed (explants) (1); explants trimmed to 0.5–1 mm (1); put explants onto agar containing nutrients and hormones (1); when explants have grown transfer to compost in greenhouse (1).

b) All have same genes since produced by mitosis from cells of the same parent plant.

c) i) Kinetin causes growth of shoots (1); auxin causes growth of callus and roots (1).

ii) Use 2 mg per litre of auxin to cause growth of callus (1), then reduce to 0.02 mg/l and add 1 mg/l of kinetin until shoots have grown (1). Then use 2 mg/l of auxin and 0.02 mg/l of kinetin to grow roots (1).

d) One advantage from: quicker to produce large numbers of plants because only a few cells needed; plants can be produced at any time of year since grown inside; large numbers of plants can be stored easily until needed. Disadvantage: all plants have same genes, so susceptible to same diseases / could all be affected at same time (2).

3 **a)** Both 1 and 2 are tasters (1). If the gene was recessive, all their children would also be tasters, but 4 is a non-taster (1 mark for explanation or correct genetic diagram).

b) 3 is Tt (1), because if TT, she couldn't supply a 't' allele to have daughters who are non-tasters (1). Individual 7 is tt (1), because this is the only genotype that produces a taster (1).

c) Individual 5 could be either TT or Tt (1), since her husband 6 is a non-taster (tt), and so she could donate a 'T' allele from either genotype to produce a son who is Tt (1 mark for explanation or correct genetic diagram).

d) Individual 3 must have the genotype Tt (1). Individual 4 must be tt (1). So the cross produces a 1:1 ratio of tasters to non-tasters / probability is 0.5 that a child is a taster (1). (1 mark for correct genetic diagram):

	T	t
t	Tt	tt
t	Tt	tt

4 **a)** D, C, B, E, F, A (all correct = 3 marks, 1 mark if 1 or 2 wrong).

b) Mitosis (1), because there are only two cells produced / only one division / no reduction division / no pairing of homologous chromosomes (1).

c) 46

d) Any two of:
- mitosis produces two daughter cells, meiosis produces four daughter cells
- daughter cells from mitosis are genetically identical to each other and the parent cell; daughter cells from meiosis are genetically different from each other and the parent cell
- mitosis produces daughter cells with the same number of chromosomes as the parent cell / diploid to diploid; meiosis halves the chromosome number / diploid to haploid.

5 **a)** From the nucleus of an udder cell of sheep A (1).

b) Nucleus of an egg is haploid / has half set of chromosomes; nucleus of an embryo is diploid / has full set of chromosomes (1).

c) Sheep A.

d) It does not involve fertilisation of an egg by a sperm (1); the embryo grows from a body cell nucleus (udder nucleus) rather than from a zygote (1).

e) Cloning (genetically modified) animals to produce human proteins (to treat diseases) (1).
Cloning (genetically modified) animals to supply organs for transplants (1).

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Answers

Chapter 21

1 **a)** Using hot steam under high pressure.

b) The air is needed to supply oxygen for aerobic respiration of the microorganisms. It is filtered to prevent contamination by unwanted microorganisms.

c) Microorganisms produce metabolic heat that could overheat the culture. The water jacket contains circulating cold water to cool the contents of the fermenter and maintain a constant temperature.

d) Nutrients.

e) Growth would be reduced. The paddles mix the contents, so that the *Penicillium* cells are exposed to more nutrients, achieving a faster rate of growth.

2 **a)** glucose → ethanol + carbon dioxide

b) The fermentation air lock allows carbon dioxide to escape from the jar but prevents air from entering.

c) To raise the temperature of fermentation. Enzymes in the yeast will work more quickly if they are near their optimum temperature.

d) High concentrations of ethanol kill the yeast cells.

3 **a)** To kill any natural bacteria in the milk.

b) It is the optimum temperature for growth and activity of the yoghurt bacteria.

c) Proteins in the milk coagulate due to the fall in pH.

d) The drop in pH reduces the growth of the lactic acid bacteria.

e) The low pH helps to prevent the growth of other 'spoiling' microorganisms.

Chapter 22

1 **a)** 1 = restriction endonuclease; 2 = DNA ligase.

b) It is a vector, used to transfer the gene into the bacterium.

c) They are cultured in fermenters.

d) It is identical to human insulin.

2 The student's account should discuss how far xenotransplantation has been developed and what advantages have been suggested for it. It should look at what the biological problems might be, and the ethical objections. It should be a balanced account.

3 **a)** Use *Agrobacterium* to insert plasmids containing the required gene into plant cells or use a gene gun – a pellet of gold coated with DNA containing the required gene.

b) The plants are grown by micropropagation.

c) Egg cell.

4 Essay should describe a range of genetically engineered products, such as:

- products from bacteria: human insulin, enzymes, human growth hormone, etc.

- genetically modified plants, such as 'golden rice' and crops resistant to herbicide
- genetically modified animals, e.g. sheep used to produce human proteins, xenotransplantation.

The benefits of each example should be discussed.

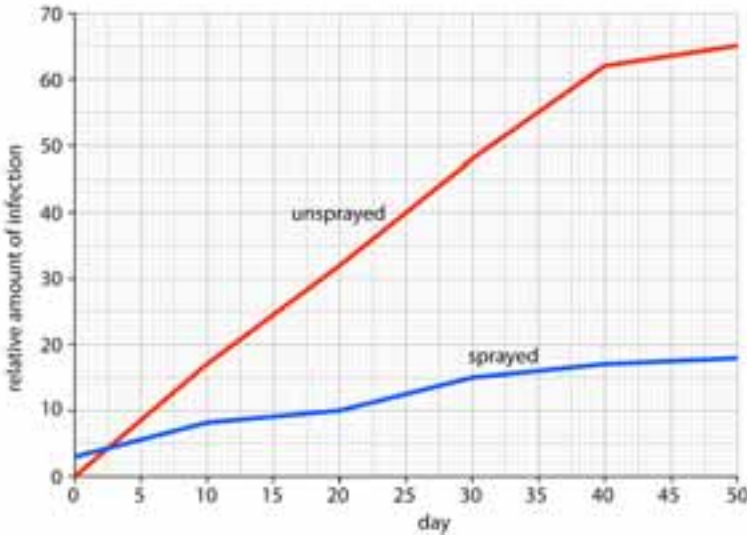
The risks from genetic engineering should also be discussed, such as:
- 'escape' of genes from crop plants into natural plant populations
- transfer of 'hidden' pathogens in xenotransplanted organs.

End of Section F Questions

1 **a)** Damages plant tissue and reduces growth; reduces amount of photosynthesis (2).

b) Used to insert a gene which confers resistance to rust disease (1).

c) i)



Award 1 mark for axes correct way round, with labels, 2 marks for each set of correctly plotted points, 1 mark for curves drawn with straight lines between data points.

ii) (Approximate values) sprayed = 11, unsprayed = 38 (2).

iii) It is necessary to know the amount of infection without spraying to be able to judge the effect of the spraying (1).

iv) Infection of the unsprayed plants was about the same as before (1). Infection of the sprayed plants had increased, due to the fungus having developed resistance to the fungicide (1).

2 **a)** It would not be possible to destroy these plants (1), and the genes could jump to other species so that they would also not be able to be destroyed (1).

b) The plants could spread to other areas and would increase as they were resistant to pests (1). The genes could jump to other species and they would also spread (1).

c) The plants could spread to other areas and would compete with other species and take over a habitat (1). The genes could jump to other species and they would also compete with other species (1).

3 **a)** To supply oxygen for aerobic respiration of the microorganisms (1).

b) The temperature must be at the optimum for the enzymes in the microorganisms to work (1). If temperature is too low, reactions will be slow / if too high enzymes will be denatured / microorganisms killed (1).

c) pH / supply of nutrients (1).

d) Disinfectants are difficult to wash out of the fermenter (1) and might kill the microorganism being grown (1) (Steam just leaves harmless water.)

e) Two marks for any two from: human insulin works better than insulin from animal pancreases / there is no risk of transfer of pathogens using human insulin / using human insulin from microorganisms is acceptable to people who object to using animal tissues.

4 **a)** i) An organism that has had genes transferred to it (1) from another species (1).

ii) A small ring of DNA (1) in the cytoplasm of a bacterium (1).

iii) A type of virus (1) that infects bacterial cells (1).

b) i) Three points from the following, for maximum of 3 marks: restriction endonucleases are enzymes that cut DNA at specific points (1). They are used to cut out genes from the DNA (1) by recognising a certain base sequence (1). Different restriction enzymes cut DNA at different places (1). Use of the same restriction enzyme on a plasmid allows the DNA to be inserted into the plasmid (1).

ii) Ligases are enzymes that join (1) cut ends of DNA (1) allowing genes to be put into plasmids (1).

5 **a)** Yeast / fungus (1).

b) In beer making, the yeast respires to produce ethanol (1);

glucose → ethanol + carbon dioxide (1 mark per side of equation).

c) Barley contains starch (1), which is broken down to maltose (1), which is used by the yeast.

d) Hops give the beer a bitter flavour (1), and stop bacteria growing (1).