

## Chapter 1

- 1 a)** Diagram should show each part of an animal cell and its function: cell membrane (controls entry and exit of substances), cytoplasm (where metabolism/reactions take place), nucleus (controls activities of cell) and mitochondria (respiration).
  - b)** A plant cell has a cell wall, a large permanent vacuole and chloroplasts (none of these are present in an animal cell).
- 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 function of the red blood cell is to transport oxygen around the body. Its biconcave disc shape gives it a large surface area to absorb oxygen. It contains the pigment haemoglobin, which combines with oxygen. The red blood cell has no nucleus, to allow it to carry more haemoglobin.
- 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.
- 7 a) Tube B / 0.85% salt solution.
- b) Tube A – no cells visible (they have burst). Tube B – normal red blood cells seen. Tube C – shrunk red blood cells with crinkly edges visible.
- c) In A (water) the cells absorb water by osmosis. They burst, releasing the red haemoglobin into solution. In B (0.85% salt solution) there is no net water movement in or out of the cells, so they remain normal in appearance. In C (3% salt solution) water is lost from the cells by osmosis, so they shrink.
- d) 0.85% salt solution is the same concentration as blood plasma, so it will not cause osmotic damage to the blood cells. Water would cause the blood cells to burst (due to entry of water by osmosis).
- 8 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 into smaller soluble molecules that can be absorbed.
- ii) 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) 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.

9

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	✓	✗	✗

- 10 a)** i) So that each of the two cells produced will have the correct number of chromosomes / correct amount of DNA after the division.
- ii) The nucleus has divided into two.
- b)** i) They (further) increase the surface area for absorption.
- ii) As the glucose moves out of the cell, the concentration inside the cell decreases and increases the concentration gradient for diffusion of glucose into the cell.

## Chapter 2

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
- 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.
  - 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.
  - 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
- 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.
  - The short distance allows easy diffusion of oxygen into the blood, and diffusion of carbon dioxide out of the blood.
  - The mucus traps bacteria and dirt particles. The cilia beat backwards and forwards to sweep these towards the mouth, preventing them entering the lungs.
  - 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 a)

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 because carbon dioxide is produced in respiration.
- c) Excretion is getting rid of a waste product; carbon dioxide is a waste product.
- d) i) Short distance allows rapid diffusion of oxygen and carbon dioxide.  
 ii) Blood brings carbon dioxide and takes away oxygen maintaining a diffusion gradient.  
 iii) Increases the surface over which diffusion of oxygen and carbon dioxide can occur.
- 6 Bronchitis is an irritation or infection of the bronchial tree. It blocks normal air flow, so the person suffering from bronchitis has difficulty breathing. Emphysema is a lung disease where the walls of the alveoli break down and fuse together, forming enlarged air spaces with reduced area for gas exchange. The patient cannot get enough oxygen into his blood and has difficulty carrying out any form of exercise.
- 7 a) Some points are:
- non-smokers have a low death rate from lung cancer at all ages
  - For 55 year-olds smoking 10 a day: about 0.5 per 1000 men (or 5 per 10 000 men)
  - 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 2.2 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.
- 8 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 3

- 1
  - a) Starch: take a sample of the water in a spotting tile and add a drop of iodine solution. The colour changes from yellow-brown 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	lipids	(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
  - short distance from gut contents to blood capillaries.

- 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)**  $\text{Energy} = (20 \times 18 \times 4.2) = 1512 \text{ joules} = 1.512 \text{ kilojoules} = 1.5 \text{ KJ}$  (to two significant figures).
- b)**  $\text{Energy per gram} = 1.512 \div 0.22 = 6.872 \text{ kJ/g}$   $6.9 \text{ kJ/g}$  (to two significant figures).
- 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 4

- 1
  - a) A = pulmonary vein, B = aorta, C = right atrium, D = left ventricle, E = renal vein.
  - b) X (artery) has narrow lumen / muscular wall, Y (vein) has large lumen / little muscle.
  - c) Hepatic vein.
- 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.
- c)** Any four from:
- helps maintain a healthy body weight / prevents obesity
  - reduces the levels of lipids / cholesterol in the blood
  - builds skeletal muscle / increases the mass / tone of muscles
  - improves the strength of tendons and ligaments
  - strengthens the diaphragm and intercostals muscles and increases the vital capacity of the lungs
  - helps maintain the level of glucose in the blood / reduces the risk of diabetes
  - reduces the risk of contracting cancers (e.g. colon cancer)
  - makes a person feel happier.
- 8 a)** The squamous epithelium cells of the capillary wall are leaky, so that the blood pressure causes fluid to leak out of the capillaries, forming the tissue fluid.
- b)** Tissue fluid forms a pathway for diffusion of substances between the capillaries and the cells. Some tissue fluid passes into the lymphatic system forming lymph.

## Chapter 5

- 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.
- 6 a)** A = eardrum, B = malleus / hammer, C = auditory nerve.
- b)** They amplify vibrations from the ear drum and pass the vibrations across the middle ear.
- c)** Vibrations of the fluid in the outer canal cause sensory hairs of receptor cells to be stretched. The receptor cells respond by producing nerve impulses in the receptor neurones.
- d)** The eustachian tube connects the middle ear with the throat. It allows pressure to be equalised either side of the eardrum (e.g. when you are going up in an aeroplane and the air pressure falls).
- e)** i) The brain determines the frequency (pitch) of sounds by detecting which hair cells are being stimulated. Those nearest the oval window are sensitive to high frequency sounds, while those nearest the round window are sensitive to low frequency sounds.
- ii) The loudness of sounds is determined by amplitude (size) of vibrations of the hair cells. Loud sounds produce high amplitude vibrations, which results in more nerve impulses per second in the sensory neurones.

## Chapter 6

- 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, E = thyroxine.
- 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 placed in a sensor.
    - iii) Controlling the amount of carbohydrate in the diet, and injections of insulin.
- 3
  - a) Negative feedback is when a change in a condition in the body is detected, and starts a process which works to return the condition to normal.
  - b) If glucose levels fall, this is detected by the pancreas, which secretes the hormone glucagon. Glucagon travels in the blood to the liver, where it stimulates the liver cells to break down stored glycogen into glucose, raising the concentration of glucose in the blood.
- 4
  - a) The thyroid gland produces the hormone thyroxine. Thyroxine stimulates the cells of the body to respire aerobically / increases the basal metabolic rate. This produces more ATP, which can be used to produce heat. Mice without thyroid glands produce less heat to maintain their body temperature.
  - b) A goitre is an enlarged thyroid gland. Thyroxine contains the element iodine. Lack of iodine in the diet causes the thyroid to swell up.

## Chapter 7

- 1
  - a)
    - i) Brain
    - ii) Spinal cord
    - iii) Heart and lungs
  - b) Cartilage is tough but flexible. It acts as a shock absorber between the vertebrae.
  - c) Any three from: bone cells / osteocytes; calcium salts / calcium phosphate; protein fibres; blood vessels; nerves.
- 2 The synovial membrane secretes synovial fluid. The synovial fluid acts as a lubricant in the joint / reduces friction. Ligaments cross the joint from bone to bone, holding the joint together.
- 3 Muscles are usually found in antagonistic pairs, such as the triceps and biceps of the arm. When the biceps contracts, it flexes the arm, whereas when the triceps contracts, it straightens or extends the arm. When muscles are exercised, they need an increased supply of energy. This is supplied by the process of cell respiration, which uses glucose and oxygen and makes carbon dioxide. Exercise also produces heat.
- 4 The essay should contain any of the following points, suitably expanded and with diagrams to illustrate the points. Regular exercise:
  - builds skeletal muscle / increases the mass / tone of muscles / explanation of muscle tone
  - improves the strength of tendons and ligaments, avoids damage to these organs
  - strengthens the diaphragm and intercostals muscles and increases the vital capacity of the lungs, improves efficiency of breathing
  - helps maintain a healthy body weight / prevents obesity / explanation of what is meant by obesity
  - reduces the levels of lipids / cholesterol in the blood / explanation of why this is beneficial to the heart
  - helps maintain the level of glucose in the blood / reduces the risk of diabetes.
  - reduces the risk of contracting cancers (e.g. colon cancer)
  - makes a person feel happier.
- 5
  - a) A = biceps (muscle); B = scapula / shoulder blade; C = triceps (muscle); D = tendon; E = ligaments; F = ulna; G = radius.
  - b) Antagonistic muscles work in pairs, one contracts while the other relaxes, to move bones at a joint.
  - c)
    - i) Ligaments cross the joint from bone to bone, holding the joint together.
    - ii) Ligaments are strong and tough, to avoid stretching, but they have some elasticity to allow joints to bend without becoming dislocated.
  - d) The biceps muscle relaxes while the triceps contracts, pulling the arm down.
- 6
  - a) Latent phase = 10 ms; contraction phase = 35 ms; relaxation phase = 50 ms.
  - b) 35 ms. The muscle is only exerting a force while it is contracting.

- c) i) To bend the arm, the biceps contracts and the triceps relaxes. To straighten the arm, the triceps contracts and the biceps relaxes.
- ii) There are pairs of (rectus) muscles either side of the spine, crossing the joints between the vertebrae. They are always in a state of partial contraction (muscle tone) to keep the spine upright.
- d) i) An endurance athlete will have large numbers of type I fibres, fewer type IIa fibres and fewer type IIb fibres.
- ii) A power athlete will have large numbers of type IIb fibres and fewer type IIa and type I fibres.
- e) An endurance athlete such as a marathon runner needs to maintain steady exercise over a long time period. For this, the muscle fibres need to be resistant to fatigue, respire aerobically, contract relatively slowly and produce a relatively low tension.

A power athlete needs to produce sudden bursts of muscle contraction. This needs fibres which contract rapidly and produce a high tension. Since the exercise is brief, the fibres can get their energy by anaerobic respiration, and it doesn't matter if they fatigue quickly.

## 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  $80 \text{ cm}^3$ . After drinking the water, the volume increased, reaching a peak of about  $320 \text{ cm}^3$  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)  $150 \text{ cm}^3$  is produced in 30 minutes, which is  $150 \div 30 = 5 \text{ cm}^3$  per minute.
    - The filtration rate is  $125 \text{ cm}^3$  per minute.
    - Therefore  $120 \text{ cm}^3$  is reabsorbed per minute.
    - the percentage reabsorption is:  $(120/125) \times 100 = 96\%$

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) All chemical reactions taking place in cells can continue at a steady rate / metabolism doesn't slow down in cold conditions.
- 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.  
 ii) They have a lot of muscle fibres in their walls.
- c) i) Antidiuretic hormone / ADH.  
 ii) More water has been lost as sweat.  
 iii) As concentration of water in blood decreases ADH is released from the hypothalamus and causes reabsorption of more water in kidney tubules.



## 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) 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.
- 3 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.
- 4
  - 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.
- 5
  - a) i) B;            ii) C;            iii) B;            iv) D;            v) A.
  - b) Pregnancy is most likely to result from sexual intercourse around the time of ovulation, i.e. in the middle of the menstrual cycle / around day 14. If a couple avoid having sexual intercourse at this time, the woman is less likely to become pregnant.
- 6
  - a) B. Cell division has reduced the chromosome number from 46 to 23 / to the number present in gametes.

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

**c)** Any three 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.

- 7 a)**
- i)** The diaphragm is a dome-shaped piece of rubber that a woman inserts into her vagina before intercourse. The cap covers the cervix, preventing sperm from entering the uterus. (A spermicidal cream is used with the cap, as extra protection against pregnancy).
  - ii)** The intrauterine device is a small piece of plastic or copper that is inserted through the cervix into the uterus. The IUD works by preventing a fertilised egg from implanting in the lining of the uterus. (Some IUDs contain the hormone progesterone, which thickens the mucus in the cervix, stopping sperms from getting through.)
  - iii)** The combined pill contains a mixture of oestrogen and progesterone. These hormones prevent the production of FSH and LH from the pituitary gland, which means that the follicles inside the ovary do not develop and ovulation does not take place. Without an egg being released, a woman cannot get pregnant.
- b)**
- i)** The advantages of the condom are that it is easy to obtain and use, and gives protection against sexually transmitted diseases. Its disadvantages are that it may slip off during intercourse, and has a relatively high failure rate.
  - ii)** The 'safe period' gives some protection against pregnancy. However it has a high failure rate. The woman needs to have a regular menstrual cycle, and to keep records of the cycle.

## Chapter 10

- 1
  - a) i = base / thymine; ii = base / cytosine; iii = deoxyribose / sugar; iv = phosphate; v = 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 11

- 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) 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) Mitosis, because the zygote must divide to produce more body cells with the normal chromosome number.
- 3
  - 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 affect the risk level, but environmental factors such as diet, smoking, etc. also have an effect.
- 4
  - 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.
- 5
  - a) D, C, B, E, F, A.
  - b) Mitosis, because there are only two cells produced / only one division / no reduction division / no pairing of homologous chromosomes.
  - 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.

- 6**
- a)** From the nucleus of an udder cell of sheep A.
  - b)** Nucleus of an egg is haploid / has half set of chromosomes; nucleus of an embryo is diploid / has full set of chromosomes.
  - c)** Sheep A.
  - d)** It does not involve fertilisation of an egg by a sperm; the embryo grows from a body cell nucleus (udder nucleus) rather than from a zygote.
  - e)** Cloning (genetically modified) animals to produce human proteins (to treat diseases). Cloning (genetically modified) animals to supply organs for transplants.

## Chapter 12

- 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) 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.

- 3 a) Both 1 and 2 are tasters. If the gene was recessive, all their children would also be tasters, but 4 is a non-taster.
- b) 3 is Tt, because if TT, she couldn't supply a 't' allele to have daughters who are non-tasters. Individual 7 is tt, because this is the only genotype that produces a taster.
- c) Individual 5 could be either TT or Tt, since her husband 6 is a non-taster, and so she could donate a 'T' allele from either genotype to produce a son who is Tt.
- d) Individual 3 must have the genotype Tt. Individual 4 must be tt. So the cross produces a 1:1 ratio of tasters to non-tasters / probability is 0.5 that a child is a taster.

	T	t
t	Tt	tt
t	Tt	tt

- 4 a) In a person who suffers from sickle cell anaemia, a sickle cell crisis is when sickle cells stick together, forming blockages in the capillaries, along with severe pain, especially in the joints.
- b) Bone marrow makes red blood cells. If bone marrow from a non-sufferer is transplanted successfully, it will produce normal blood cells.
- c) A person suffering from sickle cell anaemia has the genotype  $Hb^S Hb^S$ . A person who is heterozygous for the condition has the genotype  $Hb^A Hb^S$ . A diagram showing their gametes and possible children is:

	$Hb^S$	$Hb^S$
$Hb^A$	$Hb^A Hb^S$	$Hb^A Hb^S$
$Hb^S$	$Hb^S Hb^S$	$Hb^S Hb^S$

The diagram shows that 50% of their children will have the genotype  $Hb^S Hb^S$  and develop sickle cell anaemia (the other 50% have the heterozygote genotype  $Hb^A Hb^S$ ).

- d) The parasite that causes malaria spends part of its life cycle inside red blood cells. The red blood cells of carriers look normal, but because of the 40% abnormal haemoglobin they contain, they are slightly more fragile than normal cells. When the parasite enters the fragile red blood cells of a carrier, the cells often burst before the parasite has had time to develop, and the parasite dies.
- e) If there is no malaria in the US, people who are heterozygous ( $Hb^A Hb^S$ ) no longer have an advantage by being resistant to malaria. But people who are homozygous for the sickle cell allele ( $Hb^S Hb^S$ ) are at a selective disadvantage – they are more likely to die before having children, and not pass on the faulty gene. So natural selection is gradually removing the gene from the population.
- 5 a) i) Alleles are different forms of a gene.
- ii) Codominant alleles are ones that are both expressed in the phenotype.

b)

Blood group	Genotypes
A	$I^A I^A$ $I^A I^O$
B	$I^B I^B$ $I^B I^O$
AB	$I^A I^B$
O	$I^O I^O$

- c) To produce these children, the mother must have the genotype  $I^A I^O$  and the father must be  $I^B I^O$ .  
The genetic diagram is:

		Mother's gametes	
		$I^A$	$I^O$
Father's gametes	$I^B$	$I^A I^B$	$I^B I^O$
	$I^O$	$I^A I^O$ (child blood group A)	$I^O I^O$ (child blood group O)

(The couple could also produce children with blood groups AB and B.)

- 6 The probability of any child being a boy is 0.5 or 50%. The sexes of their previous children make no difference. This is because the woman's eggs carry an X chromosome, while 50% of the man's sperms carry an X and 50% a Y chromosome:

		Mother's eggs	
		X	X
Father's sperm	X	XX	XX
	Y	XY	XY

There is a 0.5 probability that the child will be female (XX) and 0.5 probability it will be male (XY).

- 7 a) i)  $X^a Y$   
ii)  $X^a X^a$   
iii)  $X^A X^a$



- b) The mother must be a carrier for the colour blindness gene, so her genotype is  $X^A X^a$ . The father has normal colour vision, so his genotype must be  $X^A Y$ .

The possible children from the cross are:

		Mother's gametes	
		$X^A$	$X^a$
Father's gametes	$X^A$	$X^A X^A$ (female with normal colour vision)	$X^A X^a$ (carrier female with normal colour vision)
	$Y$	$X^A Y$ (male with normal colour vision)	$X^a Y$ (male with colour blindness)

Since the child has red-green colour blindness, he must be male.

## Chapter 13

- 1
  - a) Diagram should show a core of DNA or RNA surrounded by a protein coat and an outer membrane derived from the host cell.
  - b) Virus particles are not cells. Viruses do not carry out any of the normal characteristics of living things except reproduction, and they can only do this parasitically. So viruses can be thought of as borderline between a living organism and a non-living chemical.
  - c) A virus reproduces by entering a cell (of the host) and taking over the host's genetic machinery to make more virus particles. Viruses can only reproduce in this way, so they are all parasites.
- 2
  - a) A = chromosome; B = cell wall; C = cell membrane.
  - b) The flagellum allows the bacterium to swim (by corkscrew-like movements).
  - c) Only a relatively few species are pathogens, most species are harmless to humans. Some free-living species carry out photosynthesis. Most bacteria are important decomposers, recycling dead organisms and waste products in the soil. Some are even used by humans to make food, such as yoghurt.
- 3 Infectious diseases are caused by microorganisms (or larger organisms such as parasitic worms), and can be passed from person to person, such as cholera. A non-infectious disease is not caused by a microorganism. It can be genetic, such as sickle cell anaemia, or caused by unhealthy activities, such as bronchitis due to smoking. (Allow any suitable examples.)
- 4
  - a) Any four from: (unprotected) sexual intercourse; drug users sharing an infected needle; infected blood transfusion; from mother to fetus across the placenta.
  - b) The body responds to infection with HIV by producing antibodies against the virus. A person who has anti-HIV antibodies in their blood is HIV positive.
  - c)
    - i) At the start of an HIV infection (X), HIV-infected helper T-lymphocytes are recognised and destroyed by the body's immune system, producing a small drop in the numbers of the lymphocytes, which are then replaced.
    - ii) Eventually the body cannot replace the lymphocytes at the same rate at which they are destroyed, producing a large drop in numbers (Y).
- 5
  - a) An endemic disease is one that is always present in a population of a particular geographic area.
  - b) An epidemic is when there is a widespread outbreak of an infectious disease, with many people becoming infected at the same time, spreading over a wide area. (To be classified as an epidemic there must be an increase in area affected by the disease, not just numbers infected.)
  - c) Any suitable example, such as influenza, polio or typhoid.
  - d) Vaccination gives a person (artificial active) immunity against a disease that is endemic in the area that the person is going to.
- 6
  - a) Phagocytosis and digestion of microorganisms, histamine production.
  - b) T-lymphocytes recognise the body cells that are infected with viruses. They destroy these infected cells by making holes in them, or by switching on a 'programmed cell death' process in the genetic code of the cell.

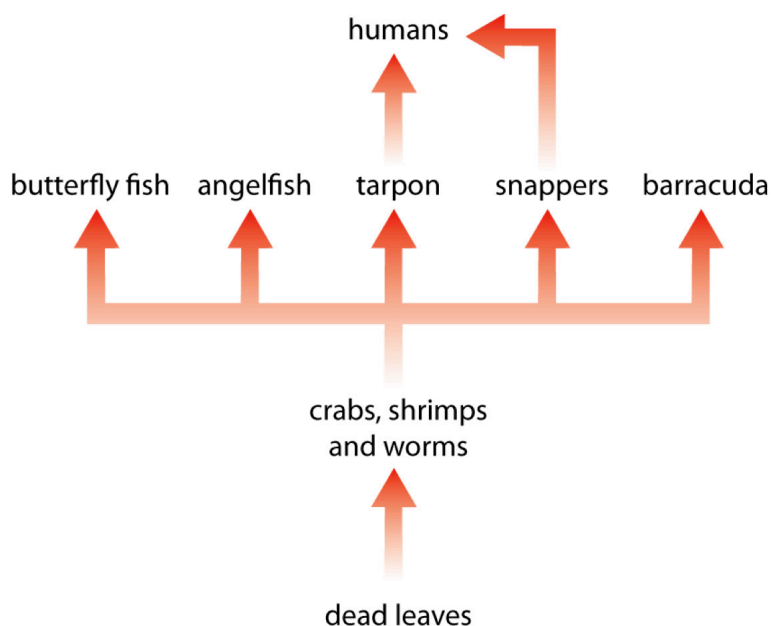
- c) Memory T-lymphocytes are produced by the body when an infection first occurs. They remain in the blood for many years and can produce a rapid secondary immune response if the person is re-infected by the same microorganism.
- 7 a) Response to the first infection = primary immune response, subsequent response = secondary immune response.
- b) The secondary immune response is faster, produces a higher level of antibodies and lasts longer than the first immune response.
- c) Antigens on a microorganism bind to receptor proteins on the surface of lymphocytes. Each lymphocyte has different receptor proteins and recognises a different antigen. The activated lymphocyte divides to produce millions more lymphocytes, which produce specific antibodies against the microorganism.
- 8 a) Any two examples, such as: syphilis, HIV / AIDS, chlamydia, hepatitis B.
- b) In men, numbers were fairly constant between 1925 and 1939. Numbers fell during the Second World War (1939-1945) but rose immediately at the end of the war or just after, to a peak in about 1946, fell sharply until 1955, then rose again until a peak in 1973, before falling again up until 1990.
- The pattern in women was similar (but lower) except that the numbers of cases in women rose during the Second World War, and the peak was in 1977. (The answer may not be as detailed as this, but general trends should be given).
- c) i) Any suitable suggestion, such as increased promiscuity (or words to that effect) / perception that gonorrhoea is not a serious disease / increased availability of the pill as a contraceptive (which does not protect against sexually transmitted diseases) / resistance of the bacterium to antibiotics.
- ii) Allow answers as in part i). Also increased sexual activity among the homosexual population as homosexuality became more widely accepted in society.
- d) Awareness of AIDS led to increased use of condoms (that give protection against sexually transmitted diseases like gonorrhoea) / decrease in 'casual' sex / any suitable correct alternative.
- e) i) penicillin interferes with the manufacture of the bacterial cell wall, which weakens it. Water enters the cell by osmosis and bursts the cell.
- ii) The bacteria may have become resistant to the penicillin.
- 9 a) Any four methods of transmission from Table 13.2, page 178, with correct examples of a disease transmitted in this way, from the last column of the Table.
- b) Any two examples of insect vector and method of transmission, such as:
- mosquito – (transmits malaria parasite) by biting and sucking blood
  - tsetse fly – (transmits sleeping sickness parasite) by biting and feeding on blood
  - flies – (transmit various pathogens, e.g. typhoid bacteria, *Salmonella*, polio virus) from faeces to human food on their bodies or in saliva.
- c) A number of control methods are possible, depending on the insects selected in b), including:
- the use of insecticides to kill adult mosquitoes / tsetse flies / flies
  - draining swamps that form the natural habitat of the larvae of malaria mosquitoes
  - the use of drugs to target the various stages of the malaria parasite's life cycle

- stocking ponds with a fish called Tilapia which feeds on the larvae of malaria mosquitoes
- the use of insect repellents, wearing long-sleeved shirts and sleeping under mosquito nets to prevent bites from the adult mosquitoes
- efficient sanitation that prevents flies landing on human faeces
- covering food / placing in a refrigerator to prevent flies landing on it.

- 10 a)**
- i) High salt concentrations make it impossible for bacteria to multiply. Bacterial cells lose water by osmosis and are killed.
  - ii) The food is heated (to between 63°C and 65°C for 30 minutes or 71.5°C for 15 seconds) which kills pathogenic bacteria.
  - iii) Food is stored in vinegar which is a weak acid that prevents most microorganisms growing.
- b)** After this date microorganisms may have increased to dangerous levels in the food.

## Chapter 14

- 1
  - a)
    - i) Algae
    - ii) Herring
  - b) The producer makes its own food by photosynthesis and is the source of all energy for the rest of the food chain.
  - c) The energy losses at each trophic level must be lower than usual, so there is enough left to support the five trophic levels.
- 2
  - a)  $(125/3050) \times 100 = 4.1\%$
  - 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.
- 3
  - 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  
 Organisms should be correctly labelled as producer, primary consumer, secondary consumer and tertiary consumer (in this order) in each chain.
    - c)
      - i) Carbon dioxide
      - ii) Decomposers feed on the detritus; their respiration produces carbon dioxide as a waste product.
- 4 Sewage causes growth of bacteria in the water. The bacteria need oxygen for growth. They use up the oxygen in the water, so the fish suffocate / die.

- 5 a) To allow solid material to settle out, i.e. sink to the bottom of the tank.  
 b) Biogas, fertiliser  
 c) Treatment in the filter bed relies on aerobic bacteria, fungi, protozoa and other organisms to digest the sewage.  
 d) Nitrates / phosphates
- 6 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 protists. An increased temperature increases their rate of photosynthesis, so they grow faster.
- 7 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.
- 8 a) Any two from: carbon dioxide, methane, water vapour, nitrous oxide, chlorofluorocarbons (CFCs).  
 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.
- 9 a)  $[(88\,600 - 886)/88\,600] \times 100 = 99\%$ .  
 b) Sulfur dioxide and nitrogen oxides are acidic gases. They are blown long distances by winds and dissolve in rain (so acidifying ground water).  
 c) Dissolved / suspended solids make water cloudy / dirty, preventing light reaching plants, so plants are unable to photosynthesise and therefore die.

## Answers to Appendix C: More Practice Questions

### Part 1: Multiple Choice Questions

Question	Answer
1	C
2	D
3	B
4	C
5	D
6	C
7	A
8	A
9	D
10	B
11	D
12	D
13	C
14	A
15	A
16	C
17	B
18	D
19	A
20	B

### Part 2: Longer structured questions requiring information from more than one chapter

- 1 One way that plant cells differ from animal cells is that plant cells have cell walls made of **cellulose**. In food chains, plants are known as producers because they can carry out the process of **photosynthesis**, which converts carbon dioxide and water into organic molecules. The first product is the sugar **glucose**, which can be respired for energy. The cells of both animals and plants have nuclei containing chromosomes. Chromosomes contain the genetic material called **deoxyribose nucleic acid / DNA**, which codes for the production of **proteins** in a cell. Bacteria lack a true nucleus, having their genetic material in a single chromosome that is loose in the cytoplasm. They also carry genes in small rings called **plasmids**. Many bacteria and fungi break down organic matter in the soil. They are known as **decomposers**. Some bacteria are pathogens, which means that they **cause disease**.

- 2 a) i) Enzyme A is from the stomach. This is because the pH is low / acidic. Enzyme B is from the small intestine / duodenum. This is because the pH is high / alkaline.  
ii) Protein.
- b) i) Protein from the microorganisms is digested by the cattle and used for growth.  
ii) The liver.  
iii) From the breakdown of protein.  
iv) The Bowman's capsule carries out ultrafiltration of the blood. This allows water and small solute molecules such as urea to pass through into the kidney tubule, but holding back blood cells and large molecules. The loop of Henlé is involved in concentrating the fluid in the tubule. This means that urine with a high concentration of urea is produced at the end of the tubule.  
v) Excretion means the removal of waste products of metabolism from the body. This applies to urea – it is a waste product from breakdown of protein.
- 3 a) Growth rates in both boys and girls are greatest in the first year after birth.
- b) i) In girls growth rate increases to a maximum between the age of about 10 and 12 years. This is due to the production of the hormone oestrogen at puberty.  
ii) In boys the growth spurt occurs somewhat later – between about 12 and 15 years. This is due to the production of the hormone testosterone at puberty.
- c) Either body mass / weight or height could be measured. Neither show changes in proportion of the different parts of the body. Both are easy to measure, although height (length) in babies is difficult to measure accurately.
- d) i) The lymph system grows quickly in order to enable immune responses to occur. This is needed because children need to develop protection from the many new pathogens they will be exposed to.  
ii) The brain grows quickly because humans need large brains to learn complex skills early in life.
- e) The secondary sexual characteristics are features of boys and girls that develop during puberty, such as development of the sex organs, growth of body hair, and growth of breasts in girls. Development of secondary sexual characteristics is controlled by the sex hormones – testosterone in boys and oestrogen in girls.

- 4 a) i) Any of the following:  
 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 (correct organism from food chain used).  
 Secondary consumer = arrow worm / large crustaceans / sand eel (correct organism from food chain used).
- iii) Herring. 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.
- b) i) Pyramid drawn correctly, with relative amounts of energy at each trophic level approximately correct (1).  
 ii)  $(892/8869) \times 100 = 10.1 \%$ .  
 iii)  $(91/892) \times 100 = 10.2 \%$ .  
 iv)  $(8869/0.1) \times 100 = 8\,869\,000 \text{ kJ}$ .  
 v) Two from: losses from respiration / in movement / as faeces / undigested food.
- c) Protein is needed for growth and repair of tissues. Lipids are needed for energy stores, insulation (in skin) and mechanical protection around organs. Vitamin D is needed for growth of bones.
- c) Suitable labelled diagram, plus description:  
 Circular muscles in gut wall behind the contents contract and longitudinal muscles relax. Gut becomes narrower, pushing contents along. Wave of contraction/relaxation passes along gut.
- d) i) The bacteria prevent the normal absorption of water from the gut contents, so more water is lost in the faeces.  
 ii) The method consists of a pack containing a solution of salts and glucose, which is mixed with sterile water. The child suffering from diarrhoea is fed the solution. This helps to rehydrate their tissues, and can prevent further damage or death.

5 a)

Part of gut	Enzyme(s) secreted	Action on bread	Other functions
mouth	(amylase)	digests starch into maltose	(saliva moistens food, teeth mechanically break down food)
stomach	pepsin	(digests protein into peptides)	(muscular churning mixes bread with enzyme)
duodenum (enzymes from pancreas)	(amylase)	digests starch into maltose	(–)
	(trypsin)	digests protein into peptides	(–)
	lipase	(digests lipid into fatty acids and glycerol)	(–)
duodenum (bile from liver)	(–)	emulsifies lipids	(bile is alkaline to help neutralise stomach acids)

- b) 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.