Answers to revision questions

1 An introduction to living organisms

1. *Any five of the following:*
- It would be able to obtain or make food.
- It would be able to respire.
- It would be able to excrete waste.
- It would be able to move its whole body or parts of its body.
- It would be able to detect and respond to changes in its environment or stimuli.
- It would be able to grow.
- It would be able to reproduce.

2. Scientists use a combination of similarities and differences between visible characteristics as well as internal structures, developmental patterns, life cycles, electron microscopic techniques and the molecular structure of deoxyribonucleic acid (DNA) to classify living organisms.

3. a) The cells of Prokaryotae lack true membrane-bound nuclei, so their DNA is free in their cells.

b)
- Protoctista
- Fungi
- Plantae or plants
- Animalia or animals

4. *Any three of the following:*
- The cells of plants have cell walls. The cells of animals lack cell walls.
- The cells of plants contain chlorophyll. The cells of animals lack chlorophyll.
- Plants make their own food by photosynthesis. Animals feed by ingesting food.
- Plants are stationary animals and do not move from place to place. Most animals can move their whole bodies from place to place.
- Any other valid difference.

5. A species is as a group of organisms of common ancestry that closely resemble each other and are normally capable of interbreeding to produce fertile offspring.

6. *Any two of the following:*
- The leaves of a monocotyledon have straight, parallel veins. The leaves of a dicotyledon have a network of veins.
- The leaves of a monocotyledon are usually long and narrow. The leaves of a dicotyledon are usually broad.
- The seeds of a monocotyledon contain one cotyledon. The seeds of a dicotyledon contain two cotyledons.
- The flower parts of a monocotyledon are in multiples of three. The flower parts of a dicotyledon are in multiples of four or five.

7. a) *Any two of the following:*
- They have one pair of antennae
- They have three pairs of legs
- The body is divided into the head, thorax and abdomen
- They have a pair of compound eyes
- Most have two pairs of wings

b) *Any two of the following:*
- They have a waterproof skin covered with scales
- They have gills for breathing
- They have fins for swimming

c) *Any two of the following:*
- They have a waterproof skin with hair and sweat glands
- They have different types of teeth
- Their young feed on milk from their mother
- They are homeothermic

d) *Any two of the following:*
- They have a waterproof exoskeleton made of chitin
- They have a segmented body
- They have several pairs of jointed legs

2 Living organisms in their environment

1. Ecology is the study of the interrelationships of living organisms with each other and with their environment.

2. a) Habitat is the place where a particular organism lives. Niche is the position or role of an organism within an ecosystem.

b) Population refers to all the members of a particular species living together in a particular habitat. Community refers to all the populations of different species living together in a particular habitat.

c) A species is a group of organisms of common ancestry that closely resemble each other and are normally capable of interbreeding to produce fertile offspring. Population refers to all the members of a particular species living together in a particular habitat.

3. *Any four of the following:*
- Pooters
- Pitfall traps
- Nets
- Plankton nets
- Tullgren funnels

4. a) Any suitable named plant, e.g. mother-in-law's tongue
Find the total area of the wasteland. Place a 1 m^2 quadrat several times at random within the wasteland and count the number of individuals of the named species found within the quadrat on each occasion. Find the total number of individuals in all the quadrats and divide this by the number of quadrats used to determine the species density, i.e. number of organisms per m^2. Finally, multiply the species density by the total area of the wasteland.

b) Collect a sample of snails and count how many are in the sample. Mark each snail with a dot of paint and release them back into the garden. Give the snails time to mix with the others in the garden and collect a second sample. Count the number of marked snails and estimate the population size using the following:

$$\text{estimated population size} = \frac{\text{number of organisms in first sample} \times \text{number of organisms in second sample}}{\text{number of marked organisms recaptured}}$$

5. Environment refers to the combination of factors which surround and act upon an organism

6. The biotic environment is composed of all the other living organisms which are present. The abiotic environment is composed of all the non-living chemical and physical factors.

7. **a)** Water is essential for photosynthesis in plants, to dissolve minerals so they can be absorbed by plant roots and to prevent the desiccation of soil organisms without waterproof body coverings such as earthworms.
   b) Oxygen in the air is essential for plant roots and soil organisms to respire aerobically, and for bacteria and fungi to decompose organic matter aerobically to form humus. Nitrogen in the air is necessary for nitrogen fixing bacteria to form inorganic nitrogenous compounds such as nitrates.
   c) Mineral nutrients are essential for the healthy growth of plants.

8. **a)** Light is essential for plants to make food by photosynthesis. Light synchronises activities of plants and animals with the seasons, such as flowering in plants, and migration, hibernation and reproduction in animals.
   b) Temperature affects the rate of photosynthesis and germination in plants and the activity of animals, for example many animals become dormant at low temperatures.
   c) Oxygen in the air is essential for aerobic respiration in almost all living organisms, carbon dioxide is essential for photosynthesis in plants, and pollutant gases have a negative effect on living organisms.

3 Interrelationships between living organisms

1. tomato plants ⟶ aphids ⟶ ladybird beetles ⟶ dragonflies ⟶ toads

2. **a)** *Any one of the following:*
   - Ladybird beetle
   - Dragonfly
   - Toad

   b) Aphid
   c) Tomato plant
   d) Aphid
   e) Ladybird beetle
   f) *Any one of the following:*
   - Ladybird beetles and aphids
   - Dragonflies and ladybird beetles
   - Toads and dragonflies

3. Decomposers are micro-organisms that feed saprophytically on dead and waste organic matter causing it to decompose.

   They are essential within ecosystems to recycle carbon dioxide and mineral nutrients.

4. A symbiotic relationship is any close relationship between two organisms of different species.

5. **a)** *Any one of the following:*
   - Leguminous plants and nitrogen fixing bacteria
     The plants gain nitrogenous compounds which they use to manufacture proteins. The bacteria gain food produced by the plants in photosynthesis, and protection.
   - Coral polyps and algae
     The polyps gain food and oxygen as the algae photosynthesise. The algae gain carbon dioxide as the polyps respire, nitrogenous compounds excreted by the polyps, and protection.
   - Termites and protozoans
     The termites gain digested food. The protozoans gain food eaten by the termites, and protection.
   - Any other valid example

   b) *Any one of the following:*
   - Epiphytes growing on trees
     The epiphytes gain support, and are positioned where they are close to sunlight and out of reach of herbivores on the ground. The trees do not gain any benefit nor are harmed.
   - Cattle egrets and cows
     The egrets gain food by eating ticks from the cow's skin and insects that the cow disturbs as it moves through grass. The cows do not gain any real benefit other than having the ticks removed from their skins, and they are not harmed.
   - Ramoras and sharks
     The ramoras gain food scraps left by the sharks as they feed. The sharks do not gain benefit nor are harmed.
   - Any other valid example

   c) *Any one of the following:*
   - Lice and ticks on mammals such as cattle
     The lice and ticks gain food by sucking blood. The cattle suffer damage to their hides, they become weak, and can also suffer from anaemia and tick paralysis.
   - Tapeworms in humans
     The tapeworms gain digested food, shelter and protection. The human suffers from abdominal pain, loss of appetite, weight loss and nausea.
   - The malaria parasite or *Plasmodium* in humans
     The parasites gain food from the human's liver and red blood cells. The human suffers from a recurrent fever.
   - Dodder or love vine on other plants
     The dodder gains food from the plant's phloem. The plant suffers from reduced growth.
   - Any other valid example

6. Food chains rarely contain more than four or five trophic levels because energy and biomass are lost at each successive level in the food chain.

7. Materials are continually recycled in nature so that they do not run out. All living organisms contain water, carbon in organic compounds and nitrogen in proteins. Water, carbon and nitrogen are continually recycled. Water is recycled to ensure plants have a continuous supply for photosynthesis, all organisms have a continuous supply to keep their cells hydrated and to act as a solvent, and aquatic organisms have a constant environment in which to live. Carbon is recycled to ensure plants have a continuous supply of carbon dioxide to manufacture organic food by photosynthesis and this ensures animals have a continuous supply of food. Nitrogen is recycled to ensure plants have

a continuous supply of nitrates to manufacture proteins and this ensures that animals and decomposers have a continuous supply of proteins.

8. *Any four of the following:*
- To prevent wastage of potentially useful materials
- To conserve natural resources
- To reduce energy usage
- To reduce the quantity of waste requiring disposal
- To reduce pollution of air, land and water

9. *Any three of the following:*
- It can be difficult to persuade households and industries to separate their waste into different types.
- It is more difficult to collect, transport and store waste items when separated into different types.
- It can be time consuming to clean and sort items.
- It can be hazardous when separating recyclable materials from toxic materials.
- It can be uneconomical because it is labour and energy intensive.
- Most small countries of the Caribbean do not have the facilities to use recycled raw materials.

4 The impact of humans on the environment

1. Non-renewable resources are present in the Earth in finite amounts and cannot be replaced, e.g. energy resources such as fossil fuels and radioactive fuels, and mineral resources. Renewable resources can be replaced by natural processes, e.g. fish, trees, soil.
Human activities are causing non-renewable resources to run out, and renewable resources to be overexploited such that their numbers are decreasing, in some cases to the point of extinction.

2. Chemical fertilisers contain nitrate and phosphate ions. If these ions enter aquatic environments in sufficient quantities they cause the rapid growth of green plants and algae. The plants and algae die and are decomposed by aerobic bacteria which multiply and use up the dissolved oxygen. This causes other aquatic organisms to die.

3. a) Sulfur dioxide causes respiratory problems and reduces the growth of green plants. It dissolves in rainwater forming acid rain which decreases the pH of the soil, damages plants, harms animals, corrodes buildings, and causes lakes, streams and rivers to become acidic and unsuitable for aquatic organisms. It also combines with water vapour and smoke, forming smog, which causes respiratory problems.

b) Carbon monoxide combines with haemoglobin more easily than oxygen, which reduces the amount of oxygen reaching body tissues. This reduces respiration in cells and mental awareness. It causes dizziness, headaches and visual impairment, and can lead to unconsciousness and death.

c) Carbon particles in smoke coat leaves, which reduces photosynthesis, and the smoke combines with water vapour and sulfur dioxide to form smog, which causes respiratory problems.

4. Toxic chemicals in the garbage can leach out and contaminate the soil, aquatic environments and water sources. Greenhouse gases can be released into the atmosphere, where they contribute to the greenhouse effect. Hydrogen sulfide gas can be released into the air and harm eyes and respiratory systems. Plastics can enter waterways and oceans, where they are harmful to aquatic organisms. Bacteria from untreated sewage can enter groundwater and cause disease. Garbage can attract rodents, which can spread disease and create an eyesore.

5.
- They contribute to the economies of Caribbean countries by providing attractions and recreational sites for tourists.
- They contribute to the economies of Caribbean countries by supporting fishing industries.
- They provide coastal protection for Caribbean countries against wave action, tidal forces and flooding.

6. *Any three of the following:*
- Carbon dioxide
- Water vapour
- Dinitrogen monoxide or nitrous oxide
- Methane
- Fluorinated gases
- Ozone

Greenhouse gases form a layer around the Earth that lets radiation from the Sun pass through, but prevents much of it being reflected back into space. This radiation causes warming of the Earth, which is known as the greenhouse effect.

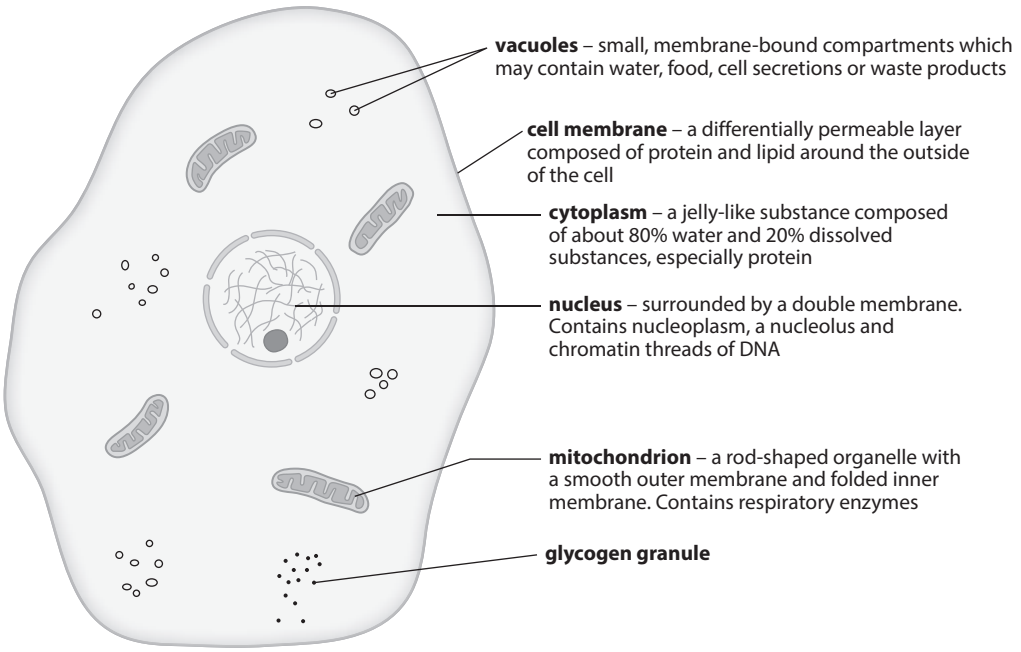
7. *Any four of the following:*
- Polar ice caps and glaciers will melt.
- Sea levels will rise.
- Low lying coastal areas will flood.
- Global weather patterns will change.
- More severe weather events and natural disasters will occur.
- Ecosystems will change.
- Some diseases will become more widespread.
- Corals will bleach and die.

8. *Any five of the following:*
- Conserve and restore natural resources, e.g. use alternative energy sources, replace renewable resources, reuse and recycle resources, reduce soil erosion, set up breeding programmes and nature reserves.
- Reduce pollution, e.g. use alternative energy sources, organic fertilisers and biodegradable pesticides, dispose of waste using appropriate methods.
- Develop educational programmes for people of all ages.
- Implement monitoring programmes to continually assess the health of ecosystems.
- Practise organic agriculture.
- Sign international agreements to control pollution and conserve natural resources.
- Pass legislation to protect the environment.
- Any other valid suggestion

9. *Any four of the following:*
- Availability of food.
- Competition for space, a mate, food and shelter.
- Spread of disease.
- Presence of predators.
- Natural disasters.
- Invasive species and pests.

5 Cells

1.



2. *Any three of the following:*
- Glycogen granules – serve as a food store.
- Cell membrane – forms a layer around the outside of the cell that controls what enters and leaves the cell.
- Cytoplasm – supports the organelles and is the site of many chemical reactions.
- Nucleus – controls the characteristics and functioning of the cell and is essential for the cell to divide.
- Mitochondrion – where respiration occurs to produce energy.

3. *Any four of the following:*
- An animal cell does not have a cell wall. A plant cell has a cell wall.
- An animal cell does not have chloroplasts or chlorophyll. A plant cell has chloroplasts containing chlorophyll.
- An animal cell may have small vacuoles with differing contents scattered throughout the cytoplasm. A plant cell has one large, central vacuole containing cell sap.
- Animal cells may contain glycogen granules as a food store. Plant cells may contain starch grains as a food store.
- Animal cells can have a variety of different shapes. Plant cells are usually round, square or rectangular.

4. A bacterial cell would lack a true nucleus and other membrane-bound organelles such as mitochondria found in other cells. Instead of a true nucleus, their DNA would be seen in a region called the nucleoid which would lack a nuclear membrane, and also in smaller regions called plasmids throughout their cytoplasm.

5. Cells in the bodies of multicellular organisms become specialised to carry out specific functions to enable multicellular organisms to carry out all essential life processes efficiently. By becoming specialised, these cells are better able to carry out their specific functions. Since the bodies of unicellular organisms consist of only one cell, this cell has to carry out all essential life processes and cannot become specialised.

6. A tissue is a group of cells all of the same type or, in some cases, more than one type, which work together to carry out a particular function.

7. Animal tissues;
Any two of the following:
- Nerve tissue. Conducts nerve impulses.
- Muscle tissue. Brings about movement.
- Epithelial tissue. Covers and protects inner and outer surfaces of the body.
- Blood tissue, a type of connective tissue. Transports substances around the body and helps fight disease.
- Adipose tissue or fat tissue, a type of connective tissue. Insulates the body, serves as a food reserve and acts as padding to protect the body.
- Any other suitable connective tissue.

Plant tissues;
Any two of the following:
- Epidermal tissue. Protects the surfaces of leaves, stems and roots.
- Packing tissue. Fills spaces in stems and roots, supports non-woody plants when turgid and stores food.
- Photosynthetic tissue. Makes food by photosynthesis.
- Vascular tissue. Transports water, mineral salts and dissolved food substances, and provides support.

8. Diffusion is the net movement of particles from an area of higher concentration to an area of lower concentration until the particles are evenly distributed.

9. *Any four of the following:*
- Oxygen, for use in aerobic respiration, moves into organisms through gaseous exchange surfaces and into cells by diffusion.

- Carbon dioxide, produced in aerobic respiration, moves out of cells and out of organisms through gaseous exchange surfaces by diffusion.
- Carbon dioxide, for use in photosynthesis, moves into leaves and plant cells by diffusion.
- Oxygen, produced in photosynthesis, moves out of plant cells and leaves by diffusion.
- Some of the glucose and amino acids produced in digestion are absorbed through the cells in the ileum and capillary walls and into the blood by diffusion.

10. Osmosis is the movement of water molecules through a differentially permeable membrane from a solution containing a lot of water molecules, e.g. a dilute solution (or water), to a solution containing fewer water molecules, e.g. a concentrated solution.

11. Water enters the cytoplasm and cell sap by osmosis. This causes the cytoplasm and vacuole to swell and press outwards on the cell wall, which causes the cell to become turgid.

12. *Any four of the following:*
- Cells are kept hydrated by water moving into them by osmosis.
- Plant cells are kept turgid by water moving into them by osmosis. This causes non-woody stems to stand upright and keeps leaves firm.
- Water is kept moving through plants by osmosis occurring in the cells of roots and leaves. This ensures that leaves get water for photosynthesis.
- The size of stomatal pores is regulated by osmosis occurring in the guard cells. This controls the loss of water from the leaves of plants.
- Water is reabsorbed into the blood from the filtrate in the kidney tubules by osmosis. This prevents the body from losing too much water.

13. Since the poison prevents respiration from occurring in the root, the energy needed to move mineral salts from the soil through the membranes of the root cells into the root cannot be made.

6 The chemistry of living organisms

1. a) Polysaccharide molecules are composed of carbon, hydrogen and oxygen atoms. These atoms form small molecules called monosaccharides which have the formula $C_6H_{12}O_6$. Polysaccharide molecules are formed by the condensation of many monosaccharide molecules into straight or branched chains and have the formula $(C_6H_{10}O_5)_n$.

b) Protein molecules are composed of carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur and phosphorus atoms. These atoms form small molecules called amino acids. Protein molecules are formed by the condensation of hundreds or thousands of amino acid molecules in long chains.

c) Lipid molecules are composed of carbon, hydrogen and oxygen atoms. Each lipid molecule is made up of four smaller molecules joined together, three fatty acid molecules and one glycerol molecule.

2. Condensation involves joining molecules together with the loss of water. Hydrolysis involves splitting molecules by adding water.

3. Test to confirm the identity of X
Add a few drops of iodine solution to X and shake. It should turn blue-black.

Test to confirm the identity of Y
Add an equal volume of Benedict's solution, shake and heat the mixture. An orange-red precipitate should form.

Test to confirm the identity of Z
Any one of the following:
- Add an equal volume of sodium hydroxide solution, shake, add drops of copper sulfate solution and shake again. It should turn purple.
- Add an equal volume of biuret reagent and shake. It should turn purple.

4. Enzymes are biological catalysts produced by all living cells. They speed up chemical reactions occurring in living organisms without being changed themselves.

5. Amylase

6. As temperature increases from 0 °C, the rate of enzyme activity increases until the optimum temperature is reached, this being about 37 °C for human enzymes. As temperature increases above the optimum temperature, the rate of enzyme activity decreases. Enzymes begin to be denatured at about 40 °C to 45 °C and most are denatured by about 55 °C.

7. *Any three of the following:*
- Enzymes are specific, each type catalyses only one type of reaction.
- Enzymes work best at a particular pH.
- Most enzymes are denatured by extremes of acidity and alkalinity.
- The action of enzymes is helped by certain vitamins and minerals.
- The action of enzymes is inhibited by certain poisons.

7 Nutrition

1. During autotrophic nutrition organisms called autotrophs use a source of energy and simple inorganic compounds such as carbon dioxide, water and minerals to manufacture complex organic food substances. During heterotrophic nutrition organisms called heterotrophs obtain ready-made organic food from their environment.

2. When an organism feeds saprophytically it obtains organic food from the dead remains of other organisms by digesting complex organic food outside their bodies and then absorbing the simpler organic substances produced.

3. A green leaf manufactures glucose by photosynthesis. During the light stage, the chlorophyll in chloroplasts of the leaf absorbs sunlight energy and uses it to split water molecules into hydrogen and oxygen. During the dark stage, the hydrogen atoms produced in the light stage reduce the carbon dioxide molecules, forming glucose. The dark stage requires enzymes.

4. $6CO_2 + 6H_2O \xrightarrow[\text{by chlorophyll}]{\text{sunlight energy absorbed}} C_6H_{12}O_6 + 6O_2$

5. *Any four of the following:*
- Waxy cuticles on the outside of both the upper and lower epidermis of the leaf are waterproof so they can prevent leaves losing water which is needed for photosynthesis.
- Stomatal pores are present throughout the lower epidermis and allow carbon dioxide to diffuse into the leaf and oxygen to diffuse out.
- The palisade mesophyll cells are directly below the upper epidermis and closest to the sunlight, and contain a large number of chloroplasts to maximise the amount of light energy absorbed.
- The palisade mesophyll cells are arranged at 90° to the leaf's surface to minimise the loss of sunlight energy that occurs as it passes through cell walls, and to allow the chloroplasts to move to the top of the cells in dim light to maximise the amount of light absorbed.
- Intercellular air spaces between the spongy mesophyll cells allow carbon dioxide to diffuse to all the mesophyll cells and oxygen to diffuse away.
- Xylem vessels in the veins running throughout the leaf supply all the mesophyll cells with water and mineral ions.

6. *Any three of the following:*
- Light
- Carbon dioxide
- Temperature
- Water

7. *Any three of the following:*
- It can be used by the leaf cells in respiration to produce energy.
- It can be condensed to starch by the leaf cells and stored for later use.
- It can be converted to other organic substances by leaf cells such as amino acids and proteins, vitamins or chlorophyll.
- It can be converted to sucrose and transported to other parts of the plant, such as growing parts and storage organs, where it can be converted to: glucose and used in respiration; cellulose and used to make cell walls in growing parts; starch and stored; amino acids and protein and used for growth; or lipids and stored, mainly in seeds.

8. Because nitrogen is necessary to make proteins and chlorophyll. Without proteins, the leaves cannot grow very large, and without the green pigment chlorophyll the leaves turn yellow.

9. A balanced diet is a diet that contains carbohydrates, proteins, lipids, vitamins, minerals, water and roughage in the correct proportions. It is needed to supply the body with enough energy for daily activities and the correct materials for growth and development, and to keep the body in a healthy state.

10. A daily diet should contain sufficient protein to make new cells for growth and to repair damaged tissues, to make enzymes which catalyse reactions in the body, to make hormones which control various processes in the body and to make antibodies to fight disease.

11.

Micronutrient	**One source**	**Functions**	**Effects of deficiency**
Vitamin C	West Indian cherries or citrus fruits or raw green vegetables or any other valid source	Keeps tissues healthy, especially the skin and connective tissue. Strengthens the immune system.	Scurvy; symptoms include swollen and bleeding gums, loose teeth or loss of teeth, red-blue spots on the skin, muscle and joint pain, wounds do not heal. Increased susceptibility to infection.
Vitamin D	Oily fish or eggs or cod liver oil or made in the body by the action of sunlight on the skin or any other valid source	Promotes the absorption of calcium and phosphorus in the ileum. Helps build and maintain strong bones and teeth. Strengthens the immune system.	Rickets in children; symptoms include soft, weak, painful, deformed bones, especially limb bones, bow legs. Osteomalacia in adults; symptoms include soft, weak, painful bones which fracture easily, weakness of limb muscles. Poor teeth.
Iron	Red meat or liver or eggs or beans or nuts or dark green leafy vegetables or any other valid source	To make haemoglobin, the red pigment in red blood cells.	Anaemia; symptoms include reduced numbers of red blood cells in the blood, pale complexion, tiredness, lack of energy.

Micronutrient	One source	Functions	Effects of deficiency
Iodine	Sea foods, e.g. fish, shellfish and seaweed or milk or eggs or any other valid source	To make the hormone thyroxine.	Cretinism in children; symptoms include retarded physical and mental development. Goitre in adults; symptoms include swollen thyroid gland in the neck. Reduced metabolic rate leading to fatigue in adults.

12. Roughage adds bulk to the food, which stimulates peristalsis. This keeps food moving through the digestive system, which helps prevent constipation and reduces the risk of colon cancer.

13. The person's age, activity and gender.

14. - Eating too little food.
- Eating too much food.
- Eating certain nutrients in the wrong proportions.

15. a) Eat a healthy, balanced diet which is low in sugar and saturated fats and high in dietary fibre supplied by fresh fruits, vegetables and whole grains. In particular, foods containing polysaccharides rather than simple sugars, and fish and lean meat rather than fatty meats should be eaten.

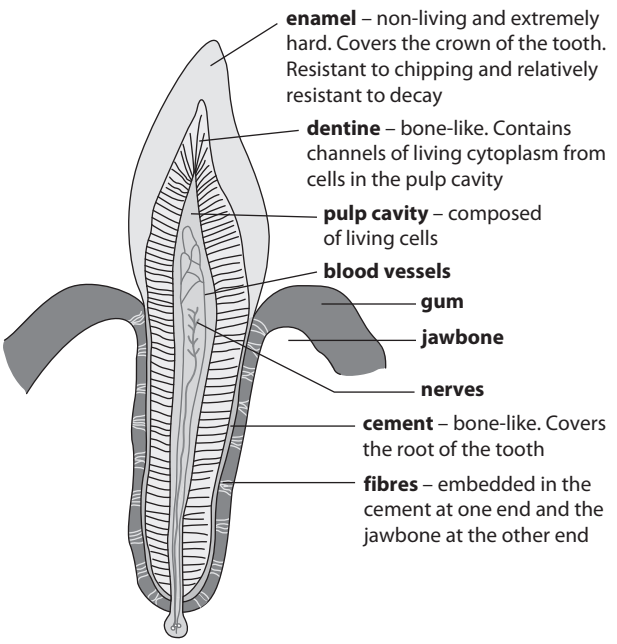
b) Eat a balanced diet which is low in saturated fat, cholesterol and salt, and high in dietary fibre, potassium, calcium and magnesium. The diet should contain plenty of fresh fruits, vegetables and whole grains together with low fat dairy products, fish and lean meat.

c) Increase the intake of foods rich in the missing nutrient or foods fortified with the missing nutrient, or take supplements containing the missing nutrient.

16. - The diet is low in saturated fats and cholesterol, therefore, vegetarians are less prone to obesity, heart disease, hypertension, diabetes and gall stones.
- The diet is high in dietary fibre, therefore vegetarians are less likely to suffer from constipation, colon cancer and certain other types of cancer.

17. During digestion food is broken down into simple, soluble food molecules which can be used for the body's activities.

18.



19. *Any three of the following:*
- Enamel – protects the tooth
- Dentine – forms the bulk of the tooth
- Blood vessels – supply the living cells of the tooth with food and oxygen and remove carbon dioxide and waste
- Fibres – anchor the tooth in the jawbone and allow slight movement for shock absorption

20. Teeth break up large pieces of food into smaller pieces. This gives the pieces a larger surface area for digestive enzymes to act on which makes chemical digestion quicker and easier, and makes food easier to swallow.

21. The sandwich contains starch, protein and lipid, which need digesting. The sandwich is chewed in the mouth to break large pieces into smaller pieces and salivary amylase begins to digest the starch into maltose. The chewed pieces of sandwich are rolled into a ball and swallowed. In the stomach, pepsin begins to digest the protein into peptides. The partially digested sandwich enters the small intestine where bile salts emulsify the lipids, pancreatic amylase continues to digest the starch into maltose, maltase digests the maltose into glucose, trypsin continues to digest the protein into peptides, peptidase or erepsin digests the peptides into amino acids and pancreatic lipase digests the lipids into fatty acids and glycerol.

22. *Any four of the following:*
- It is very long so it provides a large surface area for rapid absorption.
- Its inner surface has thousands of finger-like projections called villi which greatly increase the surface area for absorption.
- Each villus has a network of blood capillaries and a lacteal inside which provide means of rapidly transporting the products of digestion away from the ileum.
- The wall of each villus, or epithelium, is only one cell thick so that digested food can pass rapidly into the capillaries and lacteal.

- The epithelial cells have minute projections called microvilli which further increase the surface area for absorption.

23. Excess amino acids are deaminated by the liver. The nitrogen-containing amine groups are removed from the molecules and converted to urea, which enters the blood and is excreted by the kidneys. The remaining parts of the molecules are converted to glucose, which is used in respiration, or are converted to glycogen or fat and stored.

24. The pancreas secretes insulin, which stimulates body cells to absorb glucose for respiration and the liver and muscle cells to convert excess glucose to glycogen. This causes the blood glucose level to decrease to normal.

8 Respiration and gaseous exchange

1. Respiration is the process by which energy is released from food by all living cells.

2. ATP or adenosine triphosphate molecules are energy-carrying molecules which store and transport energy in living cells.
The advantages of cells producing ATP are that the energy can be released rapidly, exactly the right amount of energy can be released when needed (which prevents waste), and energy can be released exactly where it is needed in the cell.

3. Aerobic respiration uses oxygen and takes place in the mitochondria of most cells. Anaerobic respiration takes place without oxygen in the cytoplasm of some cells. Aerobic respiration always produces carbon dioxide, water and about 38 ATP molecules per molecule of glucose. The products of anaerobic respiration vary, but at least one is always organic, and it produces considerably less energy per molecule of glucose than aerobic respiration.

$$C_6H_{12}O_6 + 6O_2 \xrightarrow[\text{mitochondria}]{\text{enzymes in}} 6CO_2 + 6H_2O + \text{energy}$$

4. Anaerobic respiration releases less energy because the glucose is only partially broken down and the organic products still contain some energy, whereas the glucose is completely broken down in aerobic respiration and the products do not contain any energy.

5. During the strenuous exercise, the oxygen supply to the athlete's muscle cells eventually became too low for the demands of aerobic respiration, so his cells began to respire anaerobically and produce lactic acid. The lactic acid built up in his muscle cells and began to harm them and eventually stopped them from contracting, which caused him to collapse.
The athlete had to rest before exercising again so that his muscle cells could get rid of the lactic acid by respiring it aerobically.

6. Biogas is a mixture of approximately 60% methane, 40% carbon dioxide and traces of other contaminant gases such as hydrogen sulfide.
Biogas is produced by certain bacteria respiring organic waste under anaerobic conditions.

7. Gaseous exchange is the process by which oxygen diffuses into an organism, and carbon dioxide diffuses out of an organism, through a gaseous exchange surface.
Breathing refers to the movements in animals that bring oxygen to a gaseous exchange surface and remove carbon dioxide from the surface.

8. - They have a large surface area.
- They are very thin.
- They are moist.
- They have a rich blood supply if the organism has blood.

9. The walls of the alveoli in the lungs.

10. The external intercostal muscles between the ribs contract and the internal intercostal muscles relax, causing the ribs and sternum to move upwards and outwards. At the same time the diaphragm muscles contract, causing the diaphragm to move downwards or flatten. These movements cause the volume inside the thorax and lungs to increase and the pressure to decrease, which draws air into the lungs.

11. During the night, only respiration occurs, which uses oxygen and produces carbon dioxide, therefore, oxygen diffuses into the leaves and carbon dioxide diffuses out. As dawn approaches photosynthesis begins, which uses carbon dioxide and produces oxygen, and its rate gradually increases until it is equal to the rate of respiration. At this point, called the compensation point, there is no net movement of gases into or out of the leaves because all the carbon dioxide produced in respiration is used in photosynthesis, and all the oxygen produced in photosynthesis is used in respiration. During the day the rate of photosynthesis is greater than the rate of respiration and carbon dioxide diffuses into the leaves and the excess oxygen, which is not used in respiration, diffuses out. At about dusk the rates of photosynthesis and respiration become equal once more, and a second compensation point occurs when there is no net movement of gases in or out of the leaves.

12. The walls of the gill lamellae form the respiratory surface. The walls of the lamellae have a very large surface area because each lamella is long and thin and a fish has eight gills, each with a large number of lamellae arranged in two rows. The walls are extremely thin because they are only one cell thick. The walls are moist because the fish lives in water. The walls have a rich blood supply because each lamella has a dense network of capillaries inside it.

13. *Any four of the following:*
- Smoking cigarettes can lead to nicotine addiction.
- Smoking cigarettes reduces the oxygen-carrying capacity of the blood.
- Smoking cigarettes can cause a persistent cough to develop.
- Smoking cigarettes can lead to the development of chronic bronchitis.
- Smoking cigarettes can cause emphysema.
- Smoking cigarettes can cause cancer of the mouth, throat, oesophagus and lungs.
- Any other valid reason.

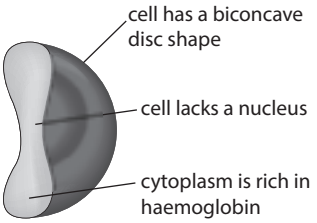
9 Transport systems

1. A monkey has a small surface area to volume ratio, so diffusion through its body surface is not adequate to supply all its body cells with their requirements and remove their

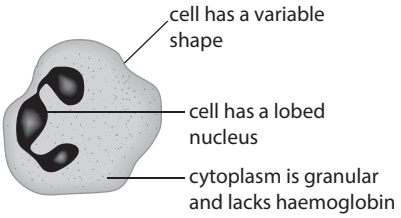
waste. Also, most of its body is too far from its surface for substances to move through it by diffusion, so it has developed a transport system to carry substances around its body.

An amoeba has a large surface area to volume ratio, so diffusion through its body surface is adequate to take in its requirements and remove its waste. Also, no part of its body is far from its surface and substances can move these short distances by diffusion, so it does not need a transport system to carry substances around its body.

2.



a red blood cell



a phagocyte

3. Red blood cell – transports oxygen from the lungs to body cells and transports small amounts of carbon dioxide from body cells to the lungs.
Phagocyte – engulfs and destroys pathogens, and engulfs pathogens which have been destroyed by antibodies.

4. When the skin is cut platelets, on exposure to air, release thromboplastin. Thromboplastin, with the help of calcium ions and vitamin K in the blood, starts a series of chemical reactions that change soluble fibrinogen into insoluble fibrin. Fibrin forms a network of fibres across the cut that trap blood cells and form a clot. The clot prevents blood loss.

5. When Alicia had chicken pox as a child, her lymphocytes made antibodies against the chicken pox antigens which slowly destroyed the virus, but not before she developed symptoms. She recovered and some of her lymphocytes developed into lymphocyte memory cells. During John's illness, if the virus entered her blood her lymphocyte memory cells immediately recognised the antigens, multiplied and quickly produced large quantities of antibodies that destroyed the virus before she developed symptoms.

6. Arteries have thick walls. Veins have thin walls. The walls of arteries are thick to withstand the high pressure of the blood, whereas veins only carry low-pressure blood. Arteries have a narrow lumen. Veins have a wide lumen. The lumen of veins is wide so it does not restrict the flow of the low-pressure blood, whereas arteries carry high-pressure blood. Arteries do not possess valves. Veins possess valves. Veins possess valves to prevent the backflow of slow flowing, low-pressure blood, whereas arteries carry fast flowing, high-pressure blood.

7. Cardiac muscle.
Cardiac muscle has its own inherent rhythm and does not get tired.

8. The bicuspid and tricuspid valves allow blood to flow from the atria to the ventricles but prevent the backflow of blood into the atria when the ventricles contract. The semi-lunar valves allow the blood to flow into the aorta and pulmonary artery but prevent the backflow of blood into the ventricles when they relax.

9. ileum → hepatic portal vein → liver → hepatic vein → posterior vena cava → right atrium → right ventricle → pulmonary vein → lungs → pulmonary artery → left atrium → left ventricle → aorta → carotid artery → brain

10. Xylem vessels transport water and mineral salts from the roots to the leaves of plants.
Xylem vessels are long, hollow tubes with no cross walls, so water can flow continuously through them. They are also extremely narrow, so capillarity helps the water move through them.

11. Water enters the root hairs and epidermal cells of roots by osmosis, and moves through the cortex cells by osmosis. This movement creates a pressure which pushes the water into the xylem and upwards into the xylem in the stem. At the same time, water evaporates from the spongy mesophyll cells around the air spaces in the leaves and the water vapour diffuses out through the stomata. This causes water to be drawn through other spongy mesophyll cells and draws water from the xylem in the leaves by osmosis. This creates a pull which draws water up the xylem in the stem. Capillarity helps water move, since the extremely narrow xylem vessels act like capillary tubes.

12. On a hot day, water evaporates and water vapour diffuses more rapidly than on a cool day. On a windy day, water vapour is carried away from the surface of the leaves so more can diffuse out, whereas on a still day water vapour remains around the leaves and very little more can diffuse out.

13. Transpiration draws water up to leaves of plants for use in photosynthesis. The moving water also carries dissolved mineral salts up to the leaves and supplies plant cells with water to keep them turgid, which supports non-woody stems and leaves. The evaporation of water from the surface of leaves cools the plant.

14. *Any four of the following:*
- Their leaves have extra thick waxy cuticles.
- Their leaves have reduced numbers of stomata.
- Their stomata are grouped together in sunken pits.
- Their stomata almost close in the daytime if temperatures are very high and open at night.
- Their leaves can roll with the stomata to the inside.
- Their leaves have fine hairs on their surface.
- The surface area of their leaves is reduced.
- They shed their leaves in the dry season or winter months.

- Their leaves, stems or roots store water.
- They have very long, deep tap roots.
- They have shallow, widespread root systems.

15. Translocation is the movement of organic food through phloem sieve tubes of plants.

16. Sugars move from the leaf cells of the mango plant into the phloem sieve tubes by active transport and water is drawn from the adjacent xylem vessels into the phloem by osmosis. This increases the pressure in the phloem which pushes sugars to the fruits, where they move out of the phloem into the cells of the fruits by active transport. Some water is also drawn into the fruits by osmosis and some is drawn into the xylem vessels by the transpiration stream. This reduces the pressure in the phloem and the difference in pressure keeps the sugars moving through the phloem from leaves to fruits.

17. *Any two of the following:*
- It overcomes the need for continuous food intake in heterotrophs and continuous food manufacture in autotrophs.
- It provides food reserves for periods of food scarcity in heterotrophs and periods when food manufacture cannot occur in autotrophs.
- It provides food reserves for special functions such as the development of embryos.

18. a) The liver stores glycogen, which is formed by condensation of excess glucose in the blood, several vitamins including A, B_{12} and D, and iron, which is formed from the breakdown of haemoglobin in red blood cells.

b) Vegetative organs are underground structures such as stem tubers, root tubers or bulbs which store food produced by the plants during the growing season. They allow the plant to survive through the unfavourable season and to grow rapidly, using stored food, at the beginning of the favourable season. The main food stored by most vegetative organs is starch.

10 Excretion and osmoregulation

1. a) Excretion is the process by which waste and harmful substances, produced by chemical reactions occurring inside body cells, i.e. the body's metabolism, are removed from the body.

b) Egestion is the removal of undigested dietary fibre and other materials from the body as faeces. Because the dietary fibre is not produced by the body's metabolism, its removal cannot be classified as excretion.

2. Many waste products are harmful and if these are not removed, they can build up in cells and damage and kill the cells.

3. Oxygen, carbon dioxide and water vapour diffuse out through the stomata of leaves and lenticels of bark-covered stems and roots. Organic waste products can be stored in dead, permanent tissue such as heart wood, or they can also be converted to insoluble substances such as oils or insoluble crystals and stored in the cells of leaves, bark, petals, fruits and seeds. They are then removed when the plant sheds these structures.

4. The kidneys, lungs, skin and liver.

5. The kidney tubules, or nephrons, produce urine in the kidney by two processes: ultra-filtration and selective reabsorption. A renal artery carries blood to each kidney. The blood then flows through a cluster of capillaries called a glomerulus.
Ultra-filtration occurs in the glomeruli. Each glomerulus is surrounded by a Bowman's capsule. The diameter of the capillary entering each glomerulus from an arteriole decreases, causing the pressure of the blood to increase. Small molecules including glucose, amino acids, hormones, vitamins, water, salts and urea are forced from the blood into the Bowman's capsule, forming filtrate.
Selective reabsorption occurs in the nephrons. Glucose, amino acids, hormones, vitamins, some water and some salts are reabsorbed from the filtrate back into the blood in the first convoluted tubule. Some water is reabsorbed in the loop of Henle, and some salts and some water are reabsorbed in the second convoluted tubule. Water is reabsorbed by osmosis, the other substances are reabsorbed by diffusion and active transport.
Filtrate containing urea, excess water and excess salts enters the collecting ducts where some water can be reabsorbed from it by osmosis. The filtrate, now called urine, travels down the collecting duct to the ureter and then to the bladder where it is stored.

6. A large quantity of urine would be produced, which contains a lot of water and very little urea and salts. Drinking a lot of water would make the body fluids too dilute. The hypothalamus of the brain would detect this and the pituitary gland would stop secreting ADH. Without ADH, the walls of the second convoluted tubules and collecting ducts would remain almost impermeable to water, so very little water would be reabsorbed from the filtrate back into the blood.

7. Treatment must occur at regular intervals to prevent waste products, mainly urea, building up in the body and poisoning cells, and also to regulate the volume and composition of blood plasma and body fluids to prevent water moving into and out of body cells unnecessarily.

11 Movement

1. Growth movements in plants are movements resulting from the plant growing, for example towards the light or with the pull of gravity. Most animals display whole body movements, which are movements of the entire body from one place to another, brought about by muscles contracting against a skeleton.

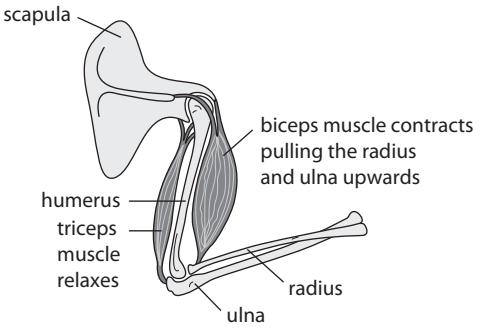
2.
- The skeleton protects the internal organs. The skull protects the brain and sense organs of the head, the vertebral column protects the spinal cord, and the ribs and sternum protect the lungs and heart.
- The skeleton supports the soft parts of the body. The vertebral column, pelvic girdle and legs are mainly responsible for support.
- The skeleton brings about movement. The limbs and vertebral column are mainly responsible for movement.
- The skeleton manufactures blood cells. The red bone marrow found in flat bones and in the ends of long bones manufactures red and white blood cells and platelets.

3. A joint is formed where two bones meet.

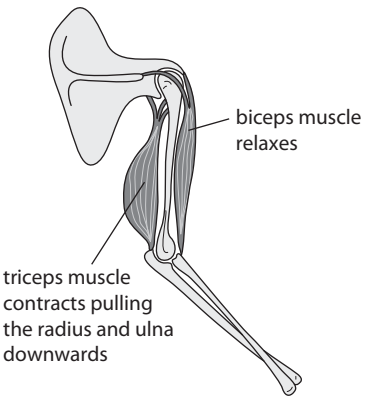
4. - Immovable joints or fibrous joints. Found between the bones of the cranium.
- Partially movable joints or cartilaginous joints. Found between adjacent vertebrae in the vertebral column.
- Moveable joints or synovial joints. Found at the elbow or the knee or the shoulder or the hip or the joints in the fingers or the joints in the toes.

5. Ligaments hold bones together at joints and they are slightly elastic to enable the bones to move at the joints. Tendons attach muscles to bones and they are non-elastic so that when a muscle contracts the force is transmitted directly to the bone causing it to move.

6.



elbow bent



elbow straightened

7. *Any four of the following:*
- Animals move to search for food.
- Animals move to search for a mate for sexual reproduction.
- Animals move to escape from predators.
- Animals move to distribute their offspring.
- Animals move to prevent overcrowding.
- Animals move to avoid danger.
- Animals move to avoid their waste products.
- Animals move to avoid harsh environmental conditions.
- Animals move to colonise new habitats.

12 Irritability

1. A stimulus is a change in the internal or external environment of an organism that initiates a response. A response is a change in an organism or part of an organism which is brought about by a stimulus.

2. Part movements:
The leaves of some plants, e.g. the sensitive plant, respond to touch or strong winds by folding, which protects them from damage. The leaves of some plants, e.g. tamarind, respond to changing light intensities by folding at night and opening in the morning to access light for photosynthesis. The flowers of some plants, e.g. hibiscus, respond to changing light intensities by opening in the morning to expose the stamens and carpels for pollination, and closing at night. Parts of insectivorous plants, e.g. Venus fly trap, move to trap prey.

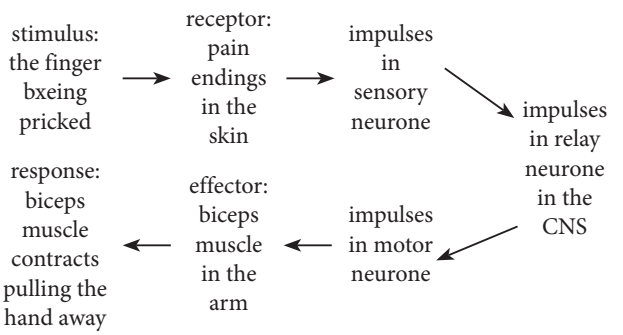
Growth movements:
Shoots grow and bend towards unilateral light and in the absence of light, or when illuminated evenly, they grow upwards against gravity to maximise the amount of light their leaves receive for photosynthesis. Growing upwards also ensures that flowers are held in the best position for pollination, and fruits and seeds for seed dispersal. Roots grow and bend downwards with the pull of gravity, which enables them to anchor the plant in the ground and to obtain water and minerals. They also grow and bend towards water to maximise the amount of water they can obtain for photosynthesis.

3. *Any three of the following:*
- Light. Most invertebrates move away from light into darkness, which makes them harder to be seen by predators.
- Moisture. Most invertebrates move away from dry areas into areas with moisture, which prevents desiccation.
- Temperature. Invertebrates move away from very low or very high temperatures, which prevents extreme temperatures affecting enzyme activity.
- Chemicals. Invertebrates move towards chemicals given off by food and away from harmful chemicals, which enables them to find food and avoid being harmed by chemicals such as pesticides.
- Touch. Invertebrates move away or curl up if touched, which helps them escape from predators or gives protection against predators.

4. - Sensory neurones transmit impulses from receptors to the central nervous system.
- Motor neurones transmit impulses from the central nervous system to effectors.
- Relay or intermediate neurones transmit impulses throughout the central nervous system, linking sensory and motor neurones.

5. A reflex action is a rapid, automatic, involuntary response to a stimulus by a muscle or gland that happens without conscious thought.

6.

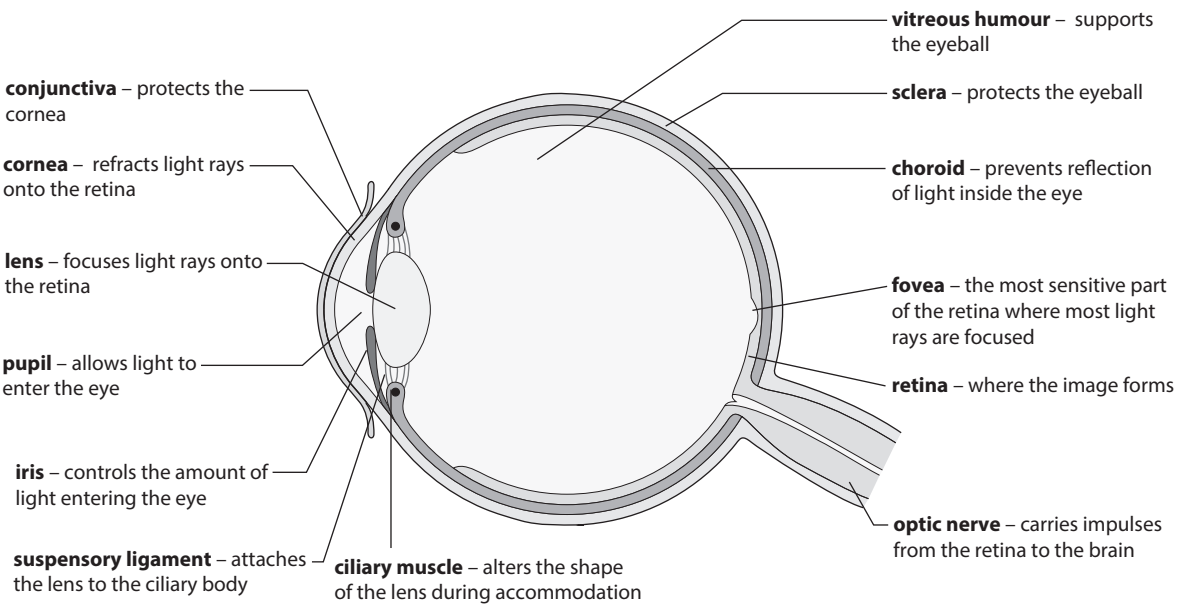


7. - Cerebrum. The cerebrum receives impulses from receptors in the skin and transmits impulses to skeletal muscles to control movement. It is also concerned with conscious thought, problem solving, decision making, planning, intelligence, emotions, memory, speech, language, hearing and sight.
- Cerebellum. The cerebellum co-ordinates movement, and controls balance and posture.
- Medulla. The medulla controls automatic activities such as heart beat, breathing and peristalsis.

8. *Any four of the following:*
- Cocaine causes feelings of well-being, increased energy, alertness, confidence and power.
- Cocaine causes bizarre, erratic, violent behaviour and hallucinations.
- Cocaine causes paranoia, anxiety and depression.
- Cocaine increases breathing rate and heart rate.
- Cocaine reduces the need for sleep.
- Cocaine damages the lungs and nasal passages.
- Cocaine causes a loss of appetite, which can lead to nutritional deficiencies and increased susceptibility to infection.
- Cocaine constricts blood vessels, which increases blood pressure and can lead to a heart attack or stroke.
- Cocaine causes schizophrenia and other mental disorders.

9. *Any four of the following:*
- Tranquillisers.
- Diet pills.
- Steroids.
- Pain killers or analgesics.
- Antibiotics.
- Caffeine.

10.



11. The cornea refracts the light rays from an object as they enter the eye and the lens refracts them again to focus them on the retina. An image of the object is formed on the retina which is inverted, reversed and smaller than the object. This stimulates the light-sensitive cells of the retina and the optic nerve carries impulses to the brain. The brain turns the image the correct way up and the correct way round and forms an impression of size, shape, colour and distance away of the object.

12. a) The circular muscles in his irises contract and the radial muscles relax. This reduces the size of his pupils, which reduces the amount of light entering his eyes.

b) The ciliary muscles in his eyes contract, which causes the suspensory ligaments to slacken. This allows the lenses to spring into a bulged shape to focus light rays from the book onto his retinas.

13. Short sight is caused by the eyeball being too long from front to back or the lens being too curved, so that light rays from near objects focus on the retina whereas light rays from distant objects focus in front of the retina. It is corrected by wearing diverging or concave lenses as spectacles or contact lenses.

14. Glaucoma is a condition in which the pressure of the fluid within the eye increases due to the flow of aqueous humour from the eye being blocked.

15. Sweating occurs and water evaporates from the sweat, which removes heat from the body. The arterioles and capillaries in the dermis of the skin dilate so more blood flows through them and more heat is lost to the environment from the blood. The hair erector muscles relax, causing the hairs to lie flat so that no insulating layer of air is created.

16. *Any four of the following:*
- The epidermis protects against pathogens entering the body.
- The epidermis, being waterproof, protects against the loss of water by evaporation from body fluids.
- The melanin in the epidermis protects against the Sun's harmful ultra-violet rays.
- The epidermis protects against harmful chemicals in the environment.
- The subcutaneous layer protects against heat loss in low environmental temperatures.
- The subcutaneous layer protects against damage by acting as padding.

17. The skin should be cleaned daily using warm water and mild cleansers and it should be patted dry. It should be moisturised daily with a moisturiser suitable for the skin type, and sunscreen should be applied daily. Skin care products containing alcohol and synthetic chemical ingredients thought to be harmful to the body should be avoided, and those containing natural ingredients should be used whenever possible.

18. Skin bleaching refers to the practice of using chemical substances to lighten skin tone or to provide an even skin complexion by reducing the production of melanin in areas of abnormal pigmentation.

13 Growth

1. Growth is a permanent increase in the size of an organism.

2. Advantages of wet mass:
It is quick and easy to measure and it doesn't harm animals. It also gives a more accurate measure of overall growth than height or length.

Disadvantages of wet mass:
The measurements may be inconsistent due to changes in water content of the bodies of organisms. Plant growth is disturbed when the plants are uprooted and the roots cleaned.

Advantage of dry mass:
It gives the most accurate measure of growth because it measures cellular and extracellular material without water.

Disadvantages of dry mass:
It is time consuming, the organisms are killed and large numbers of organisms are required.

3. Sigmoid or S-shaped.

4. The seed is surrounded by a tough outer coat called the testa which has a minute hole in it called the micropyle and a scar on it called the hilum. Inside the testa there is the embryo which consists of the plumule or embryonic shoot, the radicle or embryonic root, and two cotyledons which contain stored food.

5.
- Water is needed to activate the enzymes so that chemical reactions can occur, and also to swell the seed and break the testa.
- Oxygen is needed for aerobic respiration to produce energy.
- A suitable temperature, usually between about 5 °C and 40 °C, is needed to activate enzymes.

6. *Any one of the following:*
Green bean or other suitable example
Water is absorbed through the micropyle which activates enzymes in the cotyledons. These enzymes breakdown stored proteins into amino acids, starch into glucose and lipids into fatty acids and glycerol. The soluble substances are translocated to the radicle and plumule which use the amino acids for growth, the glucose, fatty acids and glycerol in respiration and the glucose to make the cellulose cell walls of new cells. As the radicle grows, it emerges from the testa, grows downwards and develops lateral roots which anchor the growing seedling. The top of the radical elongates and arches upwards and it pulls the cotyledons and plumule upwards. Once above ground, the cotyledons develop chlorophyll and begin to photosynthesise and the plumule grows into the first foliage leaves.

Pigeon pea or other suitable example
Water is absorbed through the micropyle which activates enzymes in the cotyledons. These enzymes breakdown stored proteins into amino acids, starch into glucose and lipids into fatty acids and glycerol. The soluble substances are translocated to the radicle and plumule which use the amino acids for growth, the glucose, fatty acids and glycerol in respiration and the glucose to make the cellulose cell walls of new cells. As the radicle grows, it emerges from the testa, grows downwards and develops lateral roots which anchor the growing seedling. The base of the plumule elongates and arches upwards and it pulls the plumule upwards. Once above ground, the plumule grows into the first foliage leaves.

7. Meristems are the only actively growing tissues in plants. They are found in specific locations and are groups of immature cells which have thin walls and which retain the ability to actively divide and grow.

8. Roots grow in length at their tips. Cells in the apical meristems in the very tips of the roots constantly divide by mitosis. Newly formed cells then rapidly elongate in the region directly behind the apical meristems, mainly by absorbing water into their vacuoles. Once fully elongated, the cells then differentiate into xylem and phloem.

9.
- Animals usually grow to a maximum size and stop growing. Plants usually grow continuously throughout their lifetime.
- Growth occurs in most tissues throughout the bodies of animals. Growth only occurs in meristems in plants.
- Growth in animals occurs mainly by cells increasing in number. Growth in plants occurs mainly by cells taking water into their vacuoles and expanding.

14 Reproduction

1. a)
- Offspring produced asexually show no variation whereas offspring produced sexually show variation.
- Asexual reproduction is a rapid process whereas sexual reproduction is a much slower process.
- The offspring produced asexually usually remain close to the parent whereas the offspring produced sexually are usually dispersed over a wide area.

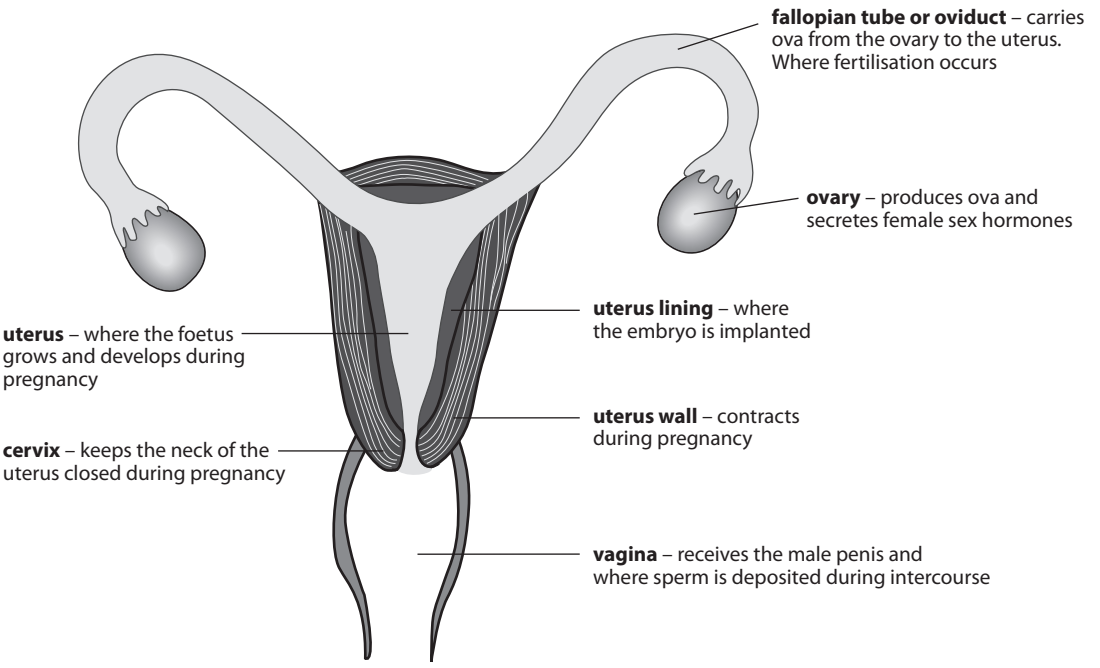
b) Advantage of asexual reproduction:
Any one of the following:
- If the parent is well adapted to its environment, all offspring will be well adapted and the chances of them all surviving will be high.
- It results in a rapid increase in the numbers of organisms in populations.

Disadvantage of asexual reproduction:
Any one of the following:
- If the environmental conditions change adversely, all offspring will be adversely affected, reducing the chances of survival of all the offspring.
- It does not enable species to change and adapt to changing environmental conditions.
- It can lead to overcrowding and competition between offspring.

Advantage of sexual reproduction:
Any one of the following:
- If the environmental conditions change, some offspring may be better adapted to the new conditions and this increases their chances of survival.
- It enables species to change and adapt to changing environmental conditions.
- The chances of overcrowding and competition between offspring are low.

Disadvantage of sexual reproduction:
Any one of the following:
- Some offspring may be better adapted to their environment than their parents, others may not be as well adapted, therefore not all offspring have an equal chance of survival.
- It results in a slow increase in the numbers of organisms in populations.

2.



3. a) Events in the ovaries:

During the first two weeks an immature ovum undergoes meiosis and one cell matures to form a mature ovum inside a Graafian follicle. Ovulation occurs on day 14 as the Graafian follicle bursts and releases the mature ovum into the oviduct. The empty Graafian follicle forms the corpus luteum, which remains for the third week and then degenerates.

Events in the uterus:
During the first week menstruation occurs as the uterus lining breaks down and is lost from the body. During the second week the uterus lining thickens and its blood supply increases. The lining remains thick for the third week and begins to break down during the fourth week, but it remains in the body.

b) Oestrogen, progesterone, follicle stimulating hormone and luteinising hormone control the menstrual cycle.

4. Ovulation and menstruation do not occur throughout the pregnancy.

5. The male becomes sexually excited and blood spaces in his penis fill with blood. His penis becomes erect and is placed into the female's vagina. Semen containing sperm is ejaculated into the top of the vagina by muscular contractions of the tubules of his epididymis and sperm ducts. The sperm swim through the cervix and uterus and into the oviducts. If an ovum is present in an oviduct, one sperm enters leaving its tail outside. A fertilisation membrane immediately develops around the ovum and the nuclei of the ovum and sperm fuse to form a zygote.

6. a) The amniotic fluid supports and protects the embryo.

b) Food and oxygen for the embryo diffuse from the mother's blood in the uterus lining into the embryo's blood in the placenta, and carbon dioxide and other waste diffuses from the embryo's blood in the placenta into the mother's blood.

c) The umbilical cord joins the embryo to the placenta. The umbilical vein in the umbilical cord carries food and oxygen from the placenta to the embryo and the umbilical artery carries carbon dioxide and other waste from the embryo to the placenta.

7.

Method	**How the method works**	**One advantage**	**One disadvantage**
The contraceptive pill	It prevents ovulation and makes the cervical mucus thicker and more difficult for sperm to swim through.	*Any one of the following:* Almost totally reliable if taken daily. Menstruation is lighter, shorter and less painful.	*Any one of the following:* Ceases to be effective if one pill is missed. May cause side effects in some women, especially those who smoke.
Surgical sterilisation	Prevents sperm leaving the male body or ova passing down the oviducts.	*Any one of the following:* Totally reliable. No need to think further about contraception. No artificial device needs to be used or pills taken, therefore, it is acceptable to all religious groups.	Usually irreversible.
The rhythm method	Intercourse is restricted to times when ova should be absent from the oviducts.	No artificial device needs to be used or pills taken, therefore, it is acceptable to all religious groups.	*Any one of the following:* Unreliable since the time of ovulation can vary. Restricts the time when intercourse can occur. Unsuitable for women with an irregular menstrual cycle.
The condom	It acts as a barrier to prevent sperm entering the female body.	*Any one of the following:* Very reliable if used correctly. Easy to use. Readily available. Protects against sexually transmitted infections.	*Any one of the following:* May reduce sensitivity so interferes with enjoyment. Condoms can tear allowing sperm to enter the vagina. Latex may cause an allergic reaction.

8. Transmission:

Any three of the following:

- Having unprotected sexual intercourse with an infected person.
- Using infected hypodermic needles or cutting instruments.
- Being given a transfusion of an infected blood product.
- From an infected mother to her baby during pregnancy and breast feeding.

Control

Any three of the following:

- All cases should be treated, especially pregnant women.
- Education programmes should be set up.
- Persons should abstain from sexual intercourse or keep to one, uninfected sexual partner.
- Condoms should be used during sexual intercourse.
- All sexual contacts of infected persons should be traced and treated.
- Persons should not use intravenous drugs or share cutting instruments.
- Sterile needles should be used for all injections.
- All human products to be given intravenously should be tested for HIV.

9. The continual spread of HIV/AIDS and other sexually transmitted infections can lead to shortened life expectancies, loss of jobs resulting in loss of earnings, increased expenditure for medical care, an increased strain on health services, discrimination, neglect by relatives and friends, parentless children and decreased standards of living.

10. Flowers are produced by flowering plants for sexual reproduction.

11. Sepals protect flowers when they are buds. Petals attract insects and birds to flowers for pollination. The nectary secretes nectar which also attracts insects and birds. The anthers of the stamens produce the pollen grains which contain male gametes needed for fertilisation and the filaments hold the anthers in the best position to deliver the pollen grains. The stigmas of the carpels catch the pollen grains and the styles hold the stigmas in the best

position to catch the pollen. The ovaries of the carpels contain the ovules and the ovules contain the female gametes needed for fertilisation. The receptacle bears all the flower parts.

12. Pollination is the transfer of pollen grains from the anthers to the stigmas of flowers.

13. *Any four of the following:*

- The flower would be large and conspicuous.
- The petals would have one or more of the following features: they would be relatively large, brightly coloured, scented, have nectaries and honey guides.
- The pollen grains would be relatively large and sticky or spiky.
- Small quantities of pollen grains would be produced.
- The anthers would be firmly attached to short, stiff filaments, and they would usually be situated inside the flower.
- The stigmas would be flat or lobed and sticky, and they would usually be situated inside the flower.

14. When a pollen grain lands on a stigma it absorbs nutrients present, swells and develops a pollen tube, which grows down through the style by secreting digestive enzymes. The tube grows through the ovary wall and the micropyle of the ovule and bursts. One male nucleus fuses with the female gamete to form the zygote. The other male nucleus and the two polar nuclei fuse to form the endosperm. The zygote divides by mitosis forming the embryo, which develops into the plumule, the radicle and one or two cotyledons. The endosperm remains in endospermic seeds and is absorbed by the cotyledons in non-endospermic seeds. The integuments become dry and develop into the testa of the seed. The ovary wall develops into the fruit, which may become succulent or dry.

15. Animals can eat succulent fruits and small seeds can pass through the digestive system unharmed, e.g. tomato, or large seeds can be discarded in a new location, e.g. mango. Fruits with hooks, e.g. castor oil, can hook onto the fur of animals and drop off in another location. Some small, light fruits or seeds develop extensions, such as wings or a parachute of hairs, which increase their surface area and they can be blown to new locations by the wind, e.g. mahogany and silk cotton seeds. The exocarp of some fruits becomes waterproof and the mesocarp becomes fibrous, making the fruit buoyant so that the fruit can be carried to a new location by water, e.g. coconut. Some plants produce thin dry fruits which split along lines of weakness and flick out their seeds, e.g. pride of Barbados.

15 Disease

1. A pathogenic disease is caused by a microscopic organism known as a pathogen, e.g. a virus, bacterium, fungus or protozoan. For example, AIDS or common cold or influenza or dengue or yellow fever or gonorrhea or syphilis or tuberculosis (TB) or cholera or athlete's foot or thrush or ringworm or malaria or amoebic dysentery or sleeping sickness or any other suitable example.

A deficiency disease is caused by the shortage or lack of a particular nutrient in the diet. For example, scurvy or anaemia or kwashiorkor or any other suitable example.
A hereditary disease is caused by an abnormal gene being passed on from one generation to the next. For example, sickle cell anaemia or cystic fibrosis or Huntingdon's disease or any other suitable example.
A physiological disease is caused by the malfunctioning of a body organ or a change in structure of certain body cells over time which causes them to not function correctly. For example, diabetes or hypertension or cancer or Alzheimer's disease or any other suitable example.

2. A vector is an organism that carries pathogens in or on its body and is not usually harmed by the pathogen.

3. The adult female lays eggs in protected areas that hold water when it rains and the eggs float on the surface of the water. A larva hatches from each egg. The larvae live in the water and hang from the surface, breathing air through breathing tubes. They feed on micro-organisms and organic matter in the water and grow. Each larva develops into a pupa. The pupae live in the water where they hang from the surface and breathe air through breathing tubes. They do not feed and the larval tissue re-organises into adult tissue in their bodies and an adult then emerges from each pupa. Adults live in and around human residences where they rest in cool, dark places during the day, and fly and feed on nectar and sugars from plants in the evenings. The adults mate and the female obtains a blood meal from a human to mature each batch of eggs before she lays them.

4. A female mosquito must obtain a blood meal from a human to mature her eggs before she lays them. If the blood contains pathogens, these pass through the walls of her intestines and move into her salivary glands where they remain and multiply throughout her lifetime. After laying each batch of eggs she requires a blood meal to mature the next batch. Each time she bites someone she injects saliva into the blood to prevent it clotting before she sucks it up, therefore she can transmit the pathogens to that person. Since mosquitoes are unharmed by the pathogens, they serve as reservoirs in which the pathogens can multiply and be continually spread to humans.

Any three of the following:
- Malaria
- Yellow fever
- Dengue
- Chikungunya
- Any other suitable example

5. Larvae and pupae can be controlled by draining all areas of standing water, adding insecticides to breeding areas to kill them, introducing fish into breeding areas to feed on them and spraying oil, kerosene or non-toxic lecithins onto still-water breeding areas to preventing them from breathing. Adults can be controlled by removing dense vegetation to reduce protection for them during daylight hours and spraying with insecticides to kill them.

6. Diseases caused by pathogens can be treated by taking drugs to relieve symptoms, using drugs, creams and ointments to kill the pathogens and giving injections of readymade antibodies to destroy pathogens. Deficiency diseases can be treated by consuming a diet containing

foods rich in the missing nutrient or foods fortified with the missing nutrient, or by taking dietary supplements containing the missing nutrient. Physiological diseases can be treated by taking drugs to relieve symptoms as they develop and using other treatments specific to the disease.

7. a) Diabetes can be controlled by eating a diet which is low in sugar and saturated fats and high in dietary fibre supplied by fresh fruits, vegetables and whole grains. In particular, diabetics should consume foods containing polysaccharides rather than simple sugars, and fish and lean meat rather than fatty meats. Diabetes can also be controlled by regular, moderate aerobic exercise such as swimming, walking and aerobics.

b) Hypertension can be controlled by eating a balanced diet which is low in saturated fat, cholesterol and salt, and high in dietary fibre, potassium, calcium and magnesium. The diet should contain plenty of fresh fruits, vegetables and whole grains together with low fat dairy products, fish and lean meat. Hypertension can also be controlled by plenty of regular aerobic exercise; at least 30 minutes daily is recommended.

8. An outbreak of a disease can cause loss of earnings as persons with the disease are unable to work. Businesses become less productive due to a reduction in hours of labour and this leads to a reduced economy. Demands on health services increase as more people have to seek treatment, and ultimately human resources are lost and standards of living are reduced.

16 Inheritance and variation

1. Chromosomes are present in the nuclei of all living cells. Each chromosome is composed of a single deoxyribonucleic acid (DNA) molecule wrapped around proteins called histones. DNA molecules contain genetic information in the form of genes. Genes are specific sections of DNA molecules and are the basic units of hereditary. Each gene controls a particular characteristic by controlling the production of protein in cells, mainly enzymes.

2. The chromosomes shorten, thicken and duplicate themselves so that each consists of two chromatids joined by the centromere. The centrioles separate forming a spindle, composed of spindle fibres, between them. The nuclear membrane disintegrates and the chromatid pairs line up around the equator of the spindle. The spindle fibres pull the chromatids to opposite poles of the cell. The cell constricts the equator to form two new cells and a nuclear membrane develops around each group of chromatids, now known as chromosomes.

3. *Any three of the following:*
- It maintains the species number of chromosomes in all members of a species.
- It ensures that each daughter cell has an identical combination of genes.
- It is essential for growth and to repair damaged tissues in multicellular organisms.
- It is the method by which organisms reproduce asexually.

4. - New plants can grow by mitosis from vegetative organs at the beginning of the growing season, for example they can grow from rhizomes, stem tubers, corms and bulbs.
- New plants can grow by mitosis from outgrowths of the parent plant, for example they can grow from runners, leaf buds or suckers.

5. Meiosis occurs in the reproductive organs during the production of gametes.

6. Four genetically non-identical cells are produced in meiosis, whereas two genetically identical cells are produced in mitosis. Each cell produced in meiosis has the haploid number of chromosomes, whereas each cell produced in mitosis has the diploid number of chromosomes. During meiosis, homologous chromosomes pair and chromatids of homologous pairs cross over each other and exchange genetic material, whereas there is no pairing of homologous chromosomes nor exchange of genetic material during mitosis.

7. - Each cell produced in meiosis has the haploid number of chromosomes so that the diploid number can then be restored when fertilisation occurs.
- Each daughter cell has a different combination of genes, which leads to variation among offspring. This enables species to constantly change and adapt to changing environmental conditions.

8. a) A gene is the basic unit of heredity and is composed of DNA, occupies a fixed position on a chromosome and determines a specific characteristic. An allele is one of a pair or series of alternative forms of a gene that occupy the same position on a particular chromosome and that control the same characteristic.

b) Genotype refers to the combination of alleles present in an organism. Phenotype refers to the observable characteristics of an organism.

c) A homozygous individual has two identical alleles in corresponding positions on a pair of homologous chromosomes. A heterozygous individual has two different alleles in corresponding positions on a pair of homologous chromosomes.

9. To produce a child that cannot taste PTC, both parents must be heterozygous.

Let: T represent the dominant allele for tasting PTC.

t represent the recessive allele for not tasting PTC.

Parental phenotype:	can taste PTC	x	can taste PTC
Parental genotype:	Tt	x	Tt
Gametes:	(T) (t)	x	(T) (t)

Random fertilisation:

Gametes	(T)	(t)
(T)	TT	Tt
(t)	Tt	tt

F_1 genotype:	TT	Tt	Tt	tt
F_1 phenotype:	can taste PTC			cannot taste PTC

10. Co-dominance occurs when neither allele dominates the other such that the influence of both alleles is visible in the heterozygous individual.

11. Let: I^A represent the co-dominant allele for blood group A
I^B represent the co-dominant allele for blood group B
I^O represent the recessive allele for blood group O
It is possible if the female's genotype is I^AI^O, but not if it is I^AI^A.

Parental phenotype:	group A		x		group AB	
Parental genotype:	I^AI^O		x		I^AI^B	
Gametes:	I^A	I^O	x		I^A	I^B

Random fertilisation:

Gametes	I^A	I^B
I^A	I^AI^A	I^AI^B
I^O	I^AI^O	I^BI^O

F_1 genotype:	I^AI^A	I^AI^B	I^AI^O	I^BI^O
F_1 phenotype:	group A	group AB	group A	group B

12. The father determines the sex of the children because only the father can pass on the Y chromosome.

Parental phenotype:	female		x		male	
Parental genotype:	XX		x		XY	
Gametes:	X	X	x		X	Y

Random fertilisation:

Gametes	X	Y
X	XX	XY
X	XX	XY

F_1 genotype:	XX	XY	XX	XY
F_1 phenotype:	female	male	female	male

13. Sex-linked characteristics are characteristics determined by genes carried on the sex-chromosomes which have nothing to do with determining gender.

14. This is possible if the female parent carries one recessive allele for colour blindness.

Parental phenotype:	female, normal vision		x		male, normal vision	
Parental genotype:	X^NX^n		x		X^NY	
Gametes:	X^N	X^n	x		X^N	Y

Random fertilisation:

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

F_1 genotype:	X^NX^N	X^NY	X^NX^n	X^nY
F_1 phenotype:	female, normal vision	male, normal vision	female, normal vision	male, colour blind

15. - It can arise as a result of meiosis because every gamete produced has a different combination of genes as a result of chromatids of homologous chromosomes crossing over and exchanging genes, and chromosomes arranging themselves around the equators of the spindles in totally random ways.
- It can arise during sexual reproduction because male and female gametes fuse in a completely random way during fertilisation to create different combinations of genes in each zygote.
- It can arise as a result of a mutation occurring, during which a single gene or part of a chromosome containing several genes suddenly changes.

16. - It enables species to adapt to changing environmental conditions, which improves their chances of survival.
- It provides the raw material on which natural selection can work, therefore, is essential for species to remain well adapted to their environment or to gradually change and improve by becoming better adapted to their environment.
- It makes it less likely that any adverse changes in environmental conditions will wipe out an entire species since some organisms may be able to adapt to the new conditions.

17. Continuous variation is where characteristics show continuous gradation from one extreme to the other without a break, for example height, weight, foot size, hair colour, and leaf size in plants. Discontinuous variation is where characteristics show clear-cut differences with no intermediates such that individuals can be divided into distinct categories, for example ABO blood groups, tongue rolling and the presence or absence of horns in cattle.

17 Species, selection and genetic engineering

1. A species is a group of organisms of common ancestry that closely resemble each other and are normally capable of interbreeding to produce fertile offspring.

2. *Any two of the following:*
- A new species may develop as a result of geographical separation.
- A new species may develop as a result of ecological separation.
- A new species may develop as a result of behavioural separation.

3. In the struggle for survival that occurs in nature, the well adapted organisms are the most likely to survive, so they are the ones most likely to reproduce and pass on their advantageous characteristics to their offspring. As a result, species remain well adapted to their environment or they gradually change and improve by becoming even better adapted, i.e. they evolve.

4. *Any two of the following:*
- Before the industrial revolution in Britain, black and white speckled peppered moths, which were eaten by birds, were well camouflaged against the pale lichen-covered tree trunks on which they rested. During the Industrial Revolution, an all-black variety appeared in the industrial areas around Manchester as a result of a

dominant mutation and it was well camouflaged against the tree trunks blackened with soot. This gave the all-black variety a selective advantage in industrial areas and, over time, it became far more numerous in these areas than the speckled variety.
- In natural populations of bacteria and various pests, a few individuals may carry genes that make them resistant to antibiotics or various pesticides. These genes arise from mutations. When exposed to antibiotics or pesticides, these resistant organisms have a selective advantage; they are more likely to survive and reproduce than non-resistant organisms and pass on their resistance to their offspring. Increasing numbers of resistant organisms are appearing within populations.
- The Galapagos Islands have at least 13 different species of finches that are possibly all descendants of a single South American species. The main difference between the species is in the shape and size of their beaks. As a result of natural selection, their beaks have become highly adapted to the different types of food present on the various islands.
- Through natural selection, anole lizards which were stranded on the four larger Caribbean islands of Cuba, Hispaniola, Jamaica and Puerto Rico independently evolved into different species with similar characteristics, which enabled them to fit similar ecological niches on each island. Today, the different species have equivalent species with similar body types on each island.

5. - By selecting and breeding sugar cane plants showing desirable characteristics, sugar cane has been bred to produce varieties with a high sucrose content, increased resistance to disease and insect pests, greater suitability to its environment and improved ratooning ability.
- By selecting and breeding Jersey, Zebu and Holstein cattle showing desirable characteristics, a breed of dairy cattle known as Jamaica Hope has been developed in Jamaica which is heat tolerant, has a high resistance to ticks and tick-borne diseases, and produces a high yield of milk, even when grazing on the poor pasturelands of the Caribbean.

6. Genetic engineering involves changing the traits of one organism by inserting genetic material from a different organism into its DNA.

7. Food production

Any two of the following:
- By inserting two genes into rice plants, one from maize and one from a soil bacterium, the endosperm of the rice grains is stimulated to produce beta-carotene which the body converts to vitamin A. This produces Golden Rice, which should help fight vitamin A deficiency.
- By inserting a gene from a soil bacterium into certain crop plants such as soyabean, corn and canola, the plants become resistant to the herbicide called 'Roundup' which can then be sprayed on the crops to destroy weeds, but not harm the crops.
- By inserting a gene from a soil bacterium into corn plants, the plants are stimulated to produce a chemical that is toxic to corn-boring caterpillars, which makes the plants resistant to the caterpillars.
- By transferring the gene that controls the production of bovine somatotrophin (BST) hormone from cattle into bacteria, the bacteria produce the hormone, which is then injected into cattle to increase milk and meat production.
- By transferring the gene that controls the production of chymosin from calf stomach cells into bacteria or fungi, the micro-organisms produce chymosin, which is used in cheese production and has considerably increased the production of cheese worldwide.
- Any other suitably described way.

Medical treatment

Any two of the following:
- By transferring the gene that controls insulin production in humans into bacteria, the bacteria produce insulin, which is used to treat diabetes.
- By transferring the gene controlling the production of human growth hormone (HGH) into bacteria, the bacteria produce the hormone, which is used to treat growth disorders in children.
- By transferring the gene controlling the production of hepatitis B antigens in the hepatitis B virus into yeast, the yeast produces the antigens, which are used as a vaccine against hepatitis B.
- Any other suitably described way.

8. Advantages

Any three of the following:
- Yields can be increased by genetic engineering, which should increase the world food supply and reduce food shortages.
- The nutritional value of foods can be increased by genetic engineering, which should reduce deficiency diseases worldwide.
- The need for chemical pesticides that harm the environment can be reduced by genetically engineering crops to be resistant to pests.
- Vaccines produced by genetic engineering are generally safer than vaccines containing live and weakened, or dead pathogens.
- Larger quantities of drugs in a safer and purer form can be produced than were previously produced from animal sources, resulting in more people worldwide having ready access to safe, life-saving drugs.
- It overcomes ethical concerns of obtaining certain drugs from animals.
- Any other suitable advantage.

Disadvantages

Any three of the following:
- Plants genetically engineered to be toxic to a pest may also be toxic to useful organisms such as insects that bring about pollination and this could negatively affect wild plants and reduce reproduction in crops, reducing food production.
- Plants genetically engineered to be resistant to pests and herbicides could create unpredictable environmental issues such as the development of pesticide-resistant insects or herbicide-resistant superweeds.

- Once a genetically modified organism is released into the environment it cannot be contained or recalled, meaning that any negative effects are irreversible.
- The number of allergens in foods could be increased by transferring genes causing allergic reactions between species.
- As yet unknown health risks may occur as a result of eating genetically modified plants and animals.
- Large companies with funds and technology to develop genetically modified organisms could make large profits at the expense of smaller companies and poorer nations.
- Future steps in genetic engineering might allow the genetic makeup of higher organisms, including humans, to be altered, leading to difficult moral and ethical issues.
- Any other suitable disadvantage.

9. *Any three of the following:*
- To determine if two DNA samples are from the same person thereby helping to solve crimes.
- To determine the paternity and, in some cases, the maternity of a child.
- To identify a body.
- To detect genetic disorders or diseases before birth or early in life so treatment can begin at an early age.
- To help genetic counsellors predict the likelihood that a child who is born to parents who have a genetic disease, or are carriers of a genetic disease, will suffer from the disease.
- To identify family relationships thereby reuniting families.
- To determine ancestral lines and create family trees.

Exam-style questions – Chapters 1 to 4

STRUCTURED QUESTIONS

1. a) i) A line transect or a belt transect **(1 mark)**

ii) Line transect

The students would place a line transect, made of a piece of string with marks at regular intervals, in a straight line across the coastal ecosystem at 90° to the shoreline from the high tide mark to the far edge of the strand woodland. They would then record the plant species touching the line at each mark.

Belt transect

The students would place two line transects, made of pieces of string, in straight lines across the coastal ecosystem at 90° to the shoreline from the high tide mark to the far edge of the strand woodland. The two transects would be a fixed distance apart, e.g. 0.5 m, and parallel to each other. They would then record the plant species found between the lines. **(3 marks)**

iii) *Any one of the following:*
- Water content of the soil.
- Mineral nutrient content of the soil.
- Humus content of the soil.
- Salinity of the soil. **(1 mark)**

b) i) The students placed the quadrat randomly five times within the pioneer zone and counted the number of individual plants of each of the three species within each quadrat. **(2 marks)**

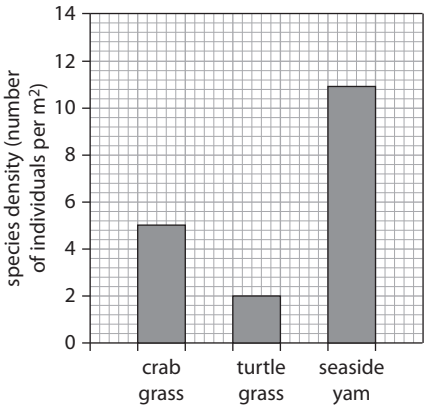
ii)

Table 1. Results from five quadrats

Species	Number of organisms in each quadrat (Q)					Species density/ number of individuals per m^2	Species frequency/ %
	Q1	Q2	Q3	Q4	Q5		
crab grass	0	5	8	3	9	5	80
turtle grass	4	3	0	3	0	2	60
seaside yam	12	9	11	13	10	11	100

(2 marks)

iii) bar chart showing the species density of there different plant species in the pioneer zone of a coastal ecosystem



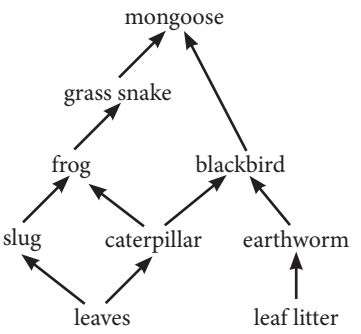
(3 marks)

iv) The water content of the soil in the pioneer zone is low and being a succulent plant, seaside yam is capable of storing water enabling it to survive with a limited water supply. **(2 marks)**

c) A pitfall trap. **(1 mark)**

Total 15 marks

2. a) i)



(3 marks)

ii) *Any one of the following:*
- Predator: frog. Prey: slug
- Predator: frog. Prey: caterpillar
- Predator: blackbird. Prey: caterpillar
- Predator: blackbird. Prey: earthworm
- Predator: grass snake. Prey: frog
- Predator: mongoose. Prey: grass snake
- Predator: mongoose. Prey: blackbird **(2 marks)**

iii) They keep the number of organisms in an ecosystem relatively constant. **(1 mark)**

iv) *Any two of the following:*
- The grass snake population would begin to decrease since grass snakes would become the mongooses' only source of food.
- The frog population would begin to increase since most of its competitors have died.

- The caterpillar population would begin to increase due to the loss of one of its predators.
- The earthworm population would increase due to the loss of its predator. **(2 marks)**

b) The number of organisms decreases at successive levels because there is less energy and biomass available at each level. Energy and biomass are lost at each level because some organic matter containing energy is lost in faeces, some is lost in organic excretory products and some is used in respiration. **(3 marks)**

c) Name of organism: nitrogen fixing bacteria.
Type of relationship: mutualism.
Benefit to the nitrogen fixing bacteria: they gain food produced by the plant in photosynthesis or they gain protection.
Benefit to the leguminous plant: it gains nitrogenous compounds which it can use to manufacture proteins. **(4 marks)**

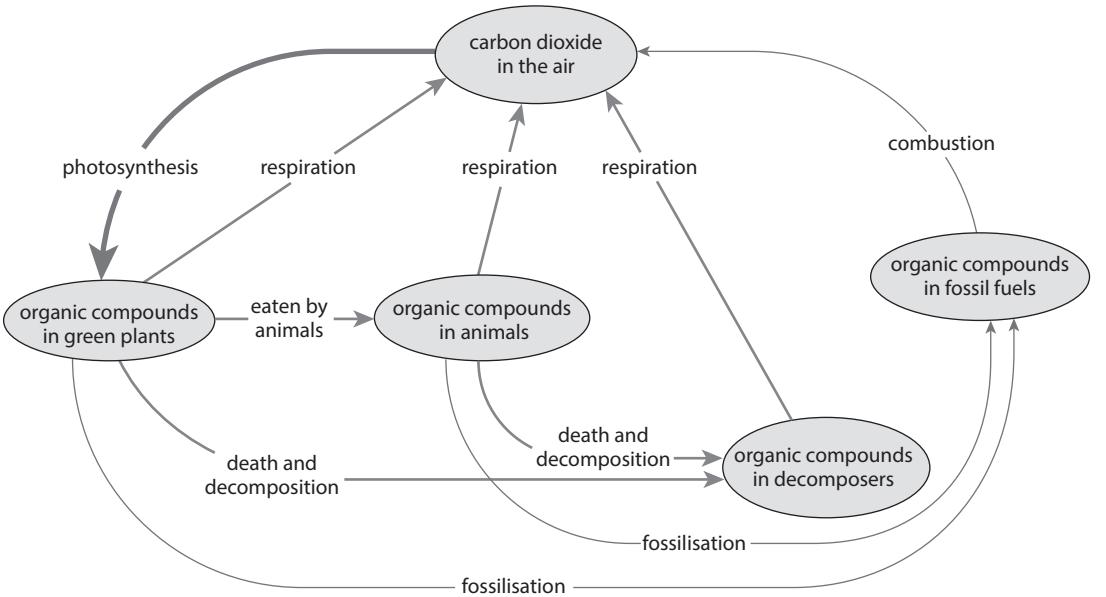
Total 15 marks

- More severe weather events and natural disasters are beginning to occur, for example, colder winters, hotter summers, more extensive and frequent floods, droughts and wildfires, and more powerful hurricanes and tornadoes.
- Ecosystems are starting to change as the numbers of some species decline whilst the numbers of others increase, as some organisms immigrate into ecosystems whilst others emigrate out, and some species become extinct.
- Certain diseases are starting to become more widespread, for example, malaria.
- Sea temperatures are starting to rise, which can cause corals to bleach and die. **(3 marks)**

iii)
- Use alternative energy sources such as solar, wind and geothermal instead of burning fossil fuels.
- Practise reforestation by replanting all trees as soon as they have been cut down.
- Any other suitable suggestion. **(2 marks)**

EXTENDED RESPONSE QUESTIONS

3. a)



(5 marks)

b) i)
- Burning fossil fuels, e.g. in industry, motor vehicles, power stations and aeroplanes, is contributing to the increasing levels of atmospheric carbon dioxide.
- Cutting down large areas of forest and not replanting the trees, i.e. deforestation is contributing to the increasing levels of atmospheric carbon dioxide. **(2 marks)**

ii) *Any three of the following:*
- Polar ice caps and glaciers are starting to melt, which is beginning to cause sea levels to rise and low-lying coastal areas to flood.
- Global weather patterns are starting to change, for example, some areas are becoming drier and others wetter than normal, whilst some areas are becoming colder and others hotter than normal.

c)
- Humans are depleting both non-renewable resources such as fossil fuels, radioactive fuels and mineral resources, and renewable resources such as fish, trees and soil. Continued depletion of non-renewable resources will ultimately lead to them running out and continued depletion of renewable resources will decrease the numbers of these organisms, in some cases to the point of extinction.
- Human activities are causing the destruction of habitats, which leads to the loss of organisms living in them; for example wetland habitats are being destroyed by pollution, overfishing and for development purposes.
- Human activities such as agriculture, industry and improper garbage disposal, are releasing waste and harmful substances into the environment that damage the environment, harm living organisms and have a

negative effect on human health. For example, sulfur dioxide, which is released when fossil fuels are burnt, causes respiratory problems and damages plants, dissolves in rainwater forming acid rain, which is harmful to both plants and animals, and can form smog, which also causes respiratory problems.

(3 marks)

Total 15 marks

4. a) *Any three of the following:*
- Humans have developed modern medicine and medical techniques over the last 150 years, which have reduced the death rate from disease, improved infant survival and increased life expectancy.
- Humans have improved water supplies, sanitation and housing over the last 150 years, all of which have reduced the death rate from disease.
- Humans have improved agricultural techniques over the last 150 years, which has increased food production and reduced the death rate from famine.
- Humans have developed a better nutritional understanding, which has improved health and life expectancy. **(6 marks)**

b) i) Marine ecosystems are aquatic ecosystems where the water contains dissolved compounds, especially salts. Marine ecosystems include coral reefs, seagrass beds, rocky and sandy shores, mangrove swamps, estuaries and the open ocean. Wetland ecosystems are transitional ecosystems where dry land meets water and the water may be fresh, brackish or salt. They are areas of land which are covered with water for either part or all of the year, and are usually found alongside rivers, lakes and coastal areas. Wetland ecosystems include mangrove swamps, freshwater swamps, marshes and bogs. **(4 marks)**

ii) *Any two of the following:*
- Marine and wetland ecosystems are being destroyed by being polluted with untreated sewage, chemical fertilisers, pesticides, industrial waste, hot water, garbage and oil from oil spills.
- Marine and wetland ecosystems are being destroyed by being over-fished.
- Marine and wetland ecosystems are being destroyed for development purposes, for example to build marinas and harbours. **(2 marks)**

iii)
- Countries will lose some of their tourist attractions and recreational sites, which will result in a decline in tourism and impact negatively on their economies.
- Countries will lose much of their flood control and protection for their shorelines against wave action and tidal forces, which will result in increased coastal erosion and a possible decline in tourism, and impact negatively on their economies.
- Countries will lose some of their natural resources such as fish, lobsters, crabs and oysters, which will result in a decline in the fishing industry and impact negatively on their economies. **(3 marks)**

Total 15 marks

Exam-style questions – Chapters 5 to 15

STRUCTURED QUESTIONS

1. a) i) X is a chloroplast.
Y is the vacuole. **(2 marks)**

ii)
- X is where the cell makes food by photosynthesis.
- Y supports the cell when it is turgid.
- Y may act as a store for food or cell waste.

(3 marks)

iii) Z is freely permeable whereas the cell membrane is differentially permeable. **(2 marks)**

iv) The cell would appear to have shrunk slightly and the cell membrane would be seen to have pulled away from the cell wall in places. **(2 marks)**

v) Cell sap and cytoplasm of the cell are more dilute than the concentrated sodium chloride solution, so water leaves the cytoplasm and cell sap through the cell membrane by osmosis and passes out through the cell wall. This causes the vacuole and cytoplasm to shrink and pull the membrane away from the cell wall. **(3 marks)**

b) i) The cell would lose its ability to control the production of protein, mainly the production of enzymes. **(1 mark)**

ii) The cell would be unable to divide and would, therefore, not live for long. For example, a red blood cell lacks a nucleus and can only live for 3 to 4 months. **(2 marks)**

Total 15 marks

2. a) i) B is a palisade mesophyll cell.
C is a xylem vessel.
D is a phloem sieve tube. **(3 marks)**

ii) Photosynthesis **(1 mark)**

iii)
- A has a thicker waxy cuticle than E. The upper surface is directly exposed to the Sun whereas the lower surface is shaded. More water is likely to evaporate from the upper surface, so the waxy cuticle needs to be thicker to prevent too much water evaporating.
- E has stomata whereas A does not. This is so that carbon dioxide can diffuse directly from the air into the air spaces throughout the spongy mesophyll and oxygen can diffuse from the air spaces directly into the air.

Or

E has stomata whereas A does not. The upper surface is directly exposed to the Sun whereas the lower surface is shaded. More water would be lost by transpiration if stomata were present in the upper epidermis, so to prevent this, the upper epidermis has no stomata. **(4 marks)**

b) i) Starch. **(1 mark)**

ii) A piece of the root tuber would be crushed with a small amount of water and a few drops of iodine solution would be added. The iodine solution would turn blue-black proving the presence of starch. **(2 marks)**

iii) The leaves of the yam plant produce sugars in photosynthesis. These sugars move from the cells

of the leaf into the phloem by active transport and water is drawn into the phloem by osmosis. This increases the pressure in the phloem, which pushes sugars to the root tubers where they move out of the phloem into the cells of the tubers by active transport. The sugars are then condensed to starch and stored in the cells. **(4 marks)**

Total 15 marks

3. a) i) P is the pulmonary artery.
Q is the aorta.
R is the left atrium.
S is the bicuspid valve. **(4 marks)**

ii) - The blood in chamber T has a higher oxygen content than the blood in chamber U.
- The blood in chamber T has a lower carbon dioxide content than the blood in chamber U. **(2 marks)**

iii) Chamber T, the left ventricle, has to pump blood longer distances around the body than chamber U, the right ventricle, which only has to pump blood a short distance to the lungs. The wall of T needs more muscle to build up more pressure to push the blood these longer distances. **(3 marks)**

b) i) - Being in the liquid state, it flows easily through blood vessels.
- Being composed mainly of water, it dissolves a large number of substances. **(2 marks)**

ii) *Any two of the following:*
- Red blood cells would be lost, so body cells would receive reduced amounts of oxygen and energy production by respiration would decrease.
- White blood cells would be lost, so the body would not be able to fight pathogenic diseases as efficiently as normal.
- Waste products such as carbon dioxide and urea would not be removed from cells efficiently, so would build up and begin to harm cells.
- The volume of the blood would decrease causing a decrease in blood pressure and a reduced amount of blood flowing to organs, in turn decreasing the amount of food and oxygen that they receive. **(2 marks)**

c) *Any two of the following:*
- Blood transporting substances around the human body moves due to the pumping action of the heart, whereas there is no pump in plants, substances move by diffusion, osmosis and active transport.
- Blood transporting substances constantly circulates around the human body, whereas water, minerals and food are transported in one direction in plants, either from roots to leaves or from sugar sources to sugar sinks.
- All substances are carried together in the blood in humans, whereas water and minerals are transported separately from dissolved food in plants. **(2 marks)**

Total 15 marks

4. a) i) Synovial joint or hinge joint. **(1 mark)**

ii) J is articular cartilage. Its function is to reduce friction between the bones or to prevent damage to the articulating surfaces.
K is the capsule. Its function is to hold the bones together but still enable movement. **(4 marks)**

iii) When a muscle contracts it exerts a pull, but it cannot exert a push when it relaxes. Therefore two muscles are always needed to move the knee joint, one to bend the joint when it contracts and the other to straighten the joint when it contracts. **(2 marks)**

iv) - The hinge joint in Figure 4 allows movement in one plane only, whereas the ball and socket joint at the hip allows movement in all planes.
- The hinge joint in Figure 4 is capable of bearing heavier loads than the ball and socket joint at the hip. **(2 marks)**

v) *Any two of the following:*
- The articular cartilage over the ends of the bones may wear away, causing increased friction between the bones as the person walks, which may cause pain.
- The synovial membrane may reduce secretion of synovial fluid, causing increased friction between the bones as the person walks, which may cause pain.
- The ligaments which make up the capsule may become weaker with age, so the bones are not held together as firmly as they should be, which may cause pain when walking. **(2 marks)**

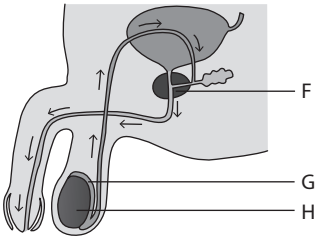
b) i) - Xylem tissue.
- Phloem tissue. **(2 marks)**

ii) The xylem vessels have tough, strong lignin in their walls which makes them strong, and the veins branch throughout the lamina of the leaf providing support for the mesophyll cells between. **(2 marks)**

Total 15 marks

5. a) i) F is the prostate gland. Its function is to secrete fluid which mixes with sperm and stimulates the sperm to swim.
G is the epididymis. Its function is to store sperm.
H is the testis. Its function is to produce sperm or to secrete male sex hormones. **(6 marks)**

ii)



(2 marks)

iii) The urethra in males carries both urine and semen to the outside of the body, whereas the urethra in females only carries urine to the outside of the body. **(1 mark)**

b) i) Wind. **(1 mark)**

ii) *Any two of the following:*
- The anthers hang outside the flower so the pollen can be easily blown off them by the wind.
- The anthers are relatively large, implying that they produce large quantities of pollen grains.
- The stigmas are outside the flower to catch the pollen grains blown by the wind.

- The stigmas are relatively large and feathery to provide a large area to catch the pollen grains.

(2 marks)

iii) *Any one of the following:*
- The pollen grains are small and light so they can be easily carried by the wind.
- Large quantities of pollen grains are produced as many are lost. **(1 mark)**

c) In flowering plants, the pollen grains containing the male gametes are carried to the stigma by an external agent such as insects or wind and a pollen tube then grows down the style for the male gametes to reach the female gametes. In humans, the sperm are placed directly into the female body by the male and they swim to the ova. **(2 marks)**

Total 15 marks

EXTENDED RESPONSE QUESTIONS

6. a) i) Breast milk should contain carbohydrates, proteins, lipids, vitamins, minerals and water in the correct proportions to supply the baby with enough energy and the correct materials for her to grow and develop, and keep her healthy. **(2 marks)**

ii) After she swallows the milk it enters her stomach where rennin clots the soluble protein to keep it in her stomach and pepsin then starts to digest the protein into peptides. The partially digested milk then leaves her stomach and enters her small intestine where organic bile salts emulsify the lipids present and pancreatic lipase digests the emulsified lipids into fatty acids and glycerol. Trypsin continues to digest the proteins into peptides and then erepsin digests the peptides into amino acids. Lactase also digests the lactose into glucose and galactose. **(6 marks)**

iii) *Any two of the following:*
- Powdered milk possibly contains a higher percentage of lipid than breast milk.
- Powdered milk possibly contains a higher percentage of lactose than breast milk.
- During feeding, the supply of formula milk is potentially unlimited, unlike the supply of breast milk. **(2 marks)**

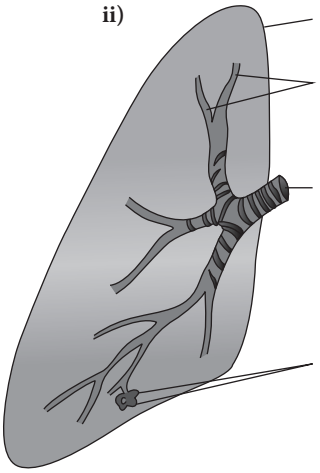
b) i) Teeth are necessary to help digest solid food because they break up large pieces of food into smaller pieces. This gives the pieces of food a larger surface area for digestive enzymes to act upon, which makes chemical digestion quicker and easier. **(3 marks)**

ii) It is important that the enamel of teeth is the hardest substance in the human body so that teeth can break up hard pieces of food without the enamel being chipped or damaged and also so that it is resistant to decay. **(2 marks)**

Total 15 marks

7. a) i) Both breathing and gaseous exchange are essential to organisms that respire aerobically to ensure that they have a continual supply of oxygen to meet the demands of aerobic respiration and to ensure that the carbon dioxide produced in respiration is continually removed so that it does not build up and poison cells. **(2 marks)**

ii)



(6 marks)

b) i) The gaseous exchange surface is the walls of all the alveoli of the lungs.
The surface is adapted for efficient gaseous exchange because each alveolus has a pocket shape and a human has two lungs, each with around 350 million alveoli to create a very large surface area to exchange large quantities of gases. The walls of the alveoli are only one cell thick so gases can diffuse through them rapidly. Each alveolus is lined with a thin layer of moisture so that gases can dissolve before they diffuse through the walls. Each alveolus is also surrounded by a dense network of capillaries so the blood flowing through them can quickly transport gases between the alveoli and the body cells. **(5 marks)**

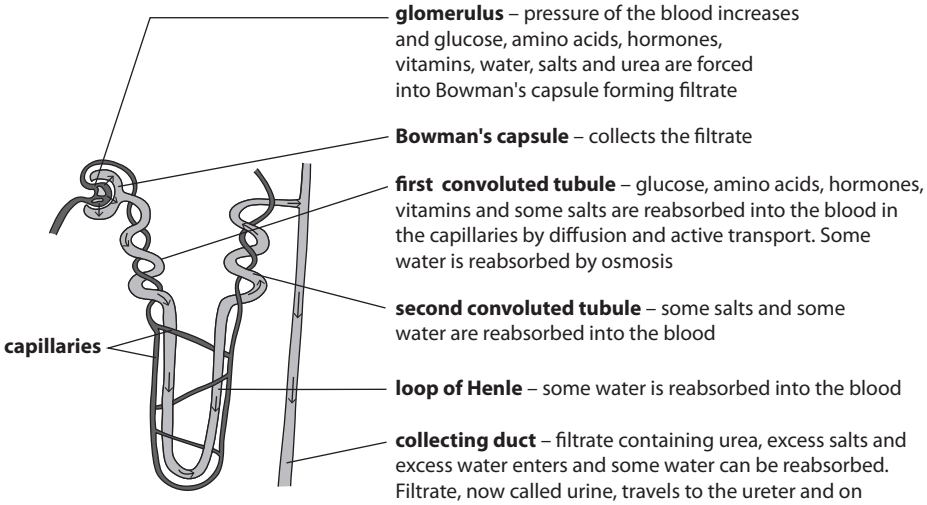
ii) *Any two of the following:*
- The carbon monoxide present in cigarette smoke combines with haemoglobin more readily than oxygen does, which reduces the amount of oxygen entering red blood cells.
- Cigarette smoke causes the production of mucus to increase and the cilia to stop beating. This results in mucus building up in the airways which can partially obstruct them, and makes it difficult to inhale and exhale sufficient air with each breath.
- Cigarette smoke irritates and inflames the walls of the bronchi and bronchioles which can partially obstruct the airways, making it difficult to inhale and exhale sufficient air with each breath.
- Cigarette smoke causes emphysema to develop. The walls between the alveoli break down, which decreases their surface area and reduces gaseous exchange.
- Cigarette smoke can cause cancer of the lungs. Normal, healthy tissue is replaced by cancerous tissue that reduces the surface area within the lungs through which gaseous exchange can occur. **(2 marks)**

Total 15 marks

8. a) i) Excretion is the process by which waste and harmful substances, produced by the chemical reactions occurring inside body cells, i.e. the body's metabolism, are removed from the body. Egestion is the removal of undigested dietary fibre and other materials from the body as faeces.

(2 marks)

ii)



(7 marks)

b) A small quantity of urine would be produced that contains very little water and a high concentration of urea and salts.
Playing tennis in hot weather would cause a lot of sweat to be produced and the loss of water in this sweat, which is not being replaced by drinking, would make the body fluids too concentrated. The hypothalamus of the brain would detect that the blood plasma is too concentrated and it would stimulate the pituitary gland to secrete antidiuteric hormone (ADH). The blood would carry the ADH to the kidneys where it would make the walls of the second convoluted tubules and the collecting ducts more permeable to water so that most of the water would be reabsorbed from the filtrate back into the blood. **(6 marks)**

Total 15 marks

9. a) i) A receptor is the part of an organism which detects a stimulus, and an effector is the part of an organism which responds to the stimulus.

(2 marks)

ii) The sight of her son falling down stimulates the light sensitive cells of his mother's retina and impulses travel along sensory neurones in the optic nerve to her brain. The impulses travel from the sensory neurones into relay neurons in her brain. The relay neurones take the impulses down her spinal cord and they then travel from the relay neurons into motor neurons at the bottom of her spinal cord. The motor neurons take the impulses out of her spinal cord to the muscles of her legs, causing them to contract, which enables her to run to her son's assistance. **(5 marks)**

b) Effects of short term abuse of alcohol on the body's ability to respond to stimuli:
Alcohol depresses the central nervous system, slowing down the transmission of nerve impulses which slows down the body's ability to respond to stimuli. It slows down reflexes, reduces muscular co-ordination, impairs muscular skills and mental functioning, reduces concentration, impairs judgement, causes blurred vision, slurred speech, increased urine production and drowsiness, and can lead to unconsciousness.
Effects of long term abuse on organs of the body:
Any two of the following:
- Alcohol abuse can cause nervous system disorders, brain damage and long-term memory loss.
- Alcohol abuse can increase blood pressure causing heart disease or a heart attack.
- Alcohol abuse can inflame stomach walls and cause stomach ulcers and other intestinal disorders.
- Alcohol abuse can affect the liver by causing the development of fatty liver disease, alcoholic hepatitis or cirrhosis.
- Alcohol abuse can cause cancer of the mouth, throat and oespohagus.
- Alcohol abuse can cause delirium tremens, a condition characterised by body tremors, anxiety and hallucinations.

Effects of alcohol abuse on society:
Any four of the following:
- Alcohol abuse upsets relationships with family and friends.
- Alcohol abuse can lead to automobile accidents that can result in loss of life or permanent disability.
- Alcohol abuse can lead to job loss as the abuser is unable to work and this can reduce the standard of living of the abuser and his or her family.
- Alcohol abuse can lead to financial problems as the abuser has to constantly find funds to purchase alcohol.
- Alcohol abuse can lead to increased crime as the abuser has to constantly find funds to purchase alcohol. Crime can then lead to arrest and possible imprisonment.

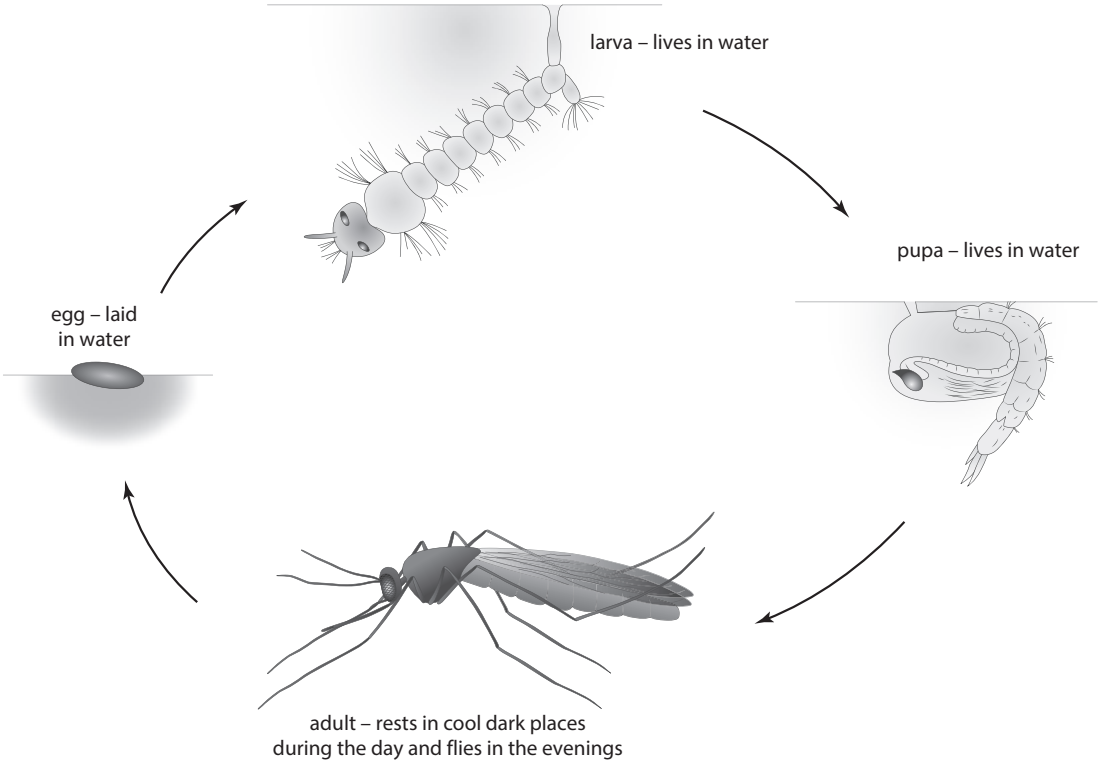
- Alcohol abuse can lead to increased demands on health services as the health of abusers deteriorates.
- Alcohol abuse can lead to prostitution as abusers have to constantly find funds to purchase alcohol; prostitution exposes abusers to sexually transmitted infections.
- Alcohol abuse places a financial burden on society as resources have to be found to rehabilitate abusers.

(8 marks)

Total 15 marks

10. a) i) A vector is an organism that carries pathogens in or on its body, transmitting the pathogens from one person to another, but it is not usually harmed by the pathogen. **(2 marks)**

ii)



(6 marks)

iii) To help prevent the spread of a disease such as malaria, yellow fever, dengue or chikungunya, the life cycle of a mosquito must be known in order to work out at which stage or stages control would be the easiest and most effective. **(2 marks)**

b) The vaccine contains cholera bacteria which have been killed; however, the bacteria's antigens are still present. The vaccine stimulates the body's lymphocytes to make antibodies against the specific cholera antigens and at the same time stimulates some lymphocytes to develop into lymphocyte memory cells. Whenever cholera bacteria enter the body the lymphocyte memory cells recognise their antigens, multiply and quickly produce large quantities of the specific antibody to destroy the pathogen before symptoms of the cholera develop. **(5 marks)**

Total 15 marks

Exam-style questions – Chapters 16 to 17

STRUCTURED QUESTIONS

1. a) i) X is a chromatid
Y is a spindle fibre.
Z is a centromere. **(3 marks)**

ii) Meiosis. **(1 mark)**

iii)
- Four of the chromatids have exchanged end segments.
- Homologous chromosomes, each composed of two chromatids, are being pulled apart to opposite poles of the cell. **(2 marks)**

iv) *Any one of the following:*
- In the testes
- In the ovaries **(1 mark)**

v) Each daughter cell would have 2 chromosomes. **(1 mark)**

vi) *Any two of the following:*
- Meiosis produces four cells that are all genetically different, whereas mitosis occurring in the embryo produces two cells that are genetically identical.
- The cells produced in meiosis have the haploid number of chromosomes, whereas the cells produced in mitosis in the embryo have the diploid number of chromosomes.
- During meiosis the homologous chromosomes pair and chromatids of homologous pairs cross over each other and exchange genetic material, whereas there is no pairing of homologous chromosomes or exchange of genetic material during mitosis in the embryo. **(2 marks)**

b) i) Cloning is the process of making genetically identical organisms through non-sexual means. **(2 marks)**

ii) - If the cuttings are taken from plants with desirable characteristics such as high yield, resistance to disease or fast growth rate, all plants produced will have the same desirable characteristics.
- Mature plants can be grown more quickly from cuttings than from seeds produced by sexual reproduction. **(2 marks)**

iii) It reduces variation in populations, which makes the plants more vulnerable if environmental conditions change adversely. **(1 mark)**

Total 15 marks

2. a) i) Using N to represent the dominant allele for normal pigmentation and n to represent the recessive allele for albinism:
- Genotype of person 1 is Nn
- Genotype of person 2 is nn **(2 marks)**

ii) The is a 25% chance that their offspring will have albinism.

Parental phenotype: normal pigmentation x normal pigmentation

Parental genotype: Nn x Nn

Gametes: (N) (n) x (N) (n)

Random fertilisation:

Gametes	(N)	(n)
(N)	NN	Nn
(n)	Nn	nn

F_1 genotype: NN Nn Nn nn

F_1 phenotype: normal pigmentation albino

(3 marks)

iii)

Parental phenotype: female with albinism x male with normal pigmentation

Parental genotype: $X^n X^n$ x $X^N Y$

Gametes: (X^n) (X^n) x (X^N) (Y)

Random fertilisation:

Gametes	(X^N)	(Y)
(X^n)	$X^N X^n$	$X^n Y$
(X^n)	$X^N X^n$	$X^n Y$

F_1 genotype: $X^N X^n$ $X^n Y$ $X^N X^n$ $X^n Y$

F_1 phenotype: female with normal pigmentation; male with albinism; female with normal pigmentation; male with albinism

(4 marks)

b) i) Discontinuous variation. **(1 mark)**

ii) *Any two of the following:*
- Tongue rolling ability.
- ABO blood groups.
- Rhesus blood groups.
- Ability to taste PTC.
- Any other suitable characteristic. **(2 marks)**

iii) *Any two of the following:*
- Variation enables species to adapt to changing environmental conditions, improving their chances of survival.
- Variation provides the raw material on which natural selection can work, therefore, it is essential for species to remain well adapted to their environment or to gradually change and improve by becoming better adapted to their environment.
- Variation makes it less likely that any adverse changes in environmental conditions will wipe out an entire species, since some organisms may be able to adapt to the new conditions. **(2 marks)**

iv) Variation is not only caused by the genetic make-up of an organisms, it arises from a combination of both genetic causes and environmental causes. **(1 mark)**

Total 15 marks

EXTENDED RESPONSE QUESTIONS

3. a) i) Genotype refers to the combination of alleles present in an organism. Phenotype refers to the observable characteristics of an organism.

ii) A dominant trait is an inherited trait that results from the presence of a single dominant allele. It is seen in an individual with one or two dominant alleles. A recessive trait is an inherited trait that results from the presence of two recessive alleles. It is only seen in an individual with no dominant allele. **(4 marks)**

b) Let: N represent the dominant allele for non-resistance
n represent the recessive allele for resistance.

Parental phenotype: non-resistant plant x resistant plant

Parental genotype: Nn x nn

Gametes: N n x n n

Random fertilisation:

Gametes	(n)	(n)
(N)	Nn	Nn
(n)	nn	nn

F_1 genotype: NN Nn nn nn

F_1 phenotype: non-resistant resistant

(4 marks)

c) i) *Any two of the following:*
- By transferring the gene which controls insulin production in humans into bacteria, the bacteria produce insulin which is used to treat diabetes.

- By transferring the gene controlling the production of human growth hormone (HGH) into bacteria, the bacteria produce the hormone, which is used to treat growth disorders in children.
- By transferring the gene controlling the production of hepatitis B antigens in the hepatitis B virus into yeast, the yeast produces the antigens, which are used as a vaccine against hepatitis B.
- Any other suitably outlined way.

In the future it should be possible to alter genes inside body cells to cure a disease or help the body fight a disease. This may be done by inserting a functional gene into cells to replace a defective gene that causes a disease, or by inactivating or 'turning off' a defective gene that causes a disease, or by introducing a gene into cells that helps the body's immune system to fight a disease. **(5 marks)**

ii) *Any two of the following:*
- Plants genetically engineered to be toxic to a pest may also be toxic to useful organisms such as insects that bring about pollination and this could negatively affect wild plants and reduce reproduction in crops, reducing food production.
- Plants genetically engineered to be resistant to pests and herbicides could create unpredictable environmental issues such as the development of pesticide-resistant insects or herbicide-resistant superweeds.
- Once a genetically modified organism is released into the environment it cannot be contained or recalled, meaning that any negative effects are irreversible.
- The number of allergens in foods could be increased by transferring genes that cause allergic reactions between species.
- As yet unknown health risks may occur as a result of eating genetically modified plants and animals.
- Future steps in genetic engineering might allow the genetic makeup of higher organisms, including humans, to be altered leading to difficult moral and ethical issues.
- Any other suitable concern. **(2 marks)**

Total 15 marks

4. a) i) A species is a group of organisms of common ancestry that closely resemble each other and are normally capable of interbreeding to produce fertile offspring.

Species remain as separate groups because they are only capable of reproducing successfully with members of the same species. It is possible that members of some closely related species can interbreed and produce offspring; however, their offspring are usually either sterile or are so biologically weak that they rarely produce offspring. **(3 marks)**

ii) *Any two of the following:*
- A new species may develop as a result of geographical separation. When a physical barrier such as a mountain range, desert, ocean, river or stream prevents two groups of organisms of the same species from meeting and interbreeding, the flow of genes between the two groups stops and genetic differences gradually develop to a point where the two groups can no longer interbreed successfully.
- A new species may develop as a result of ecological separation. When two groups of organisms of the same species inhabit the same region but they become adapted to different habitats in that region, gene flow between the two groups is reduced and genetic differences gradually develop to a point where the two groups can no longer interbreed successfully.
- A new species may develop as a result of behavioural separation. When animals exhibit elaborate courtship behaviours before mating and small differences occur in any of the stimuli used, these differences can prevent mating, which prevents gene flow and genetic differences gradually develop to a point where the organisms can no longer interbreed successfully. **(4 marks)**

b) In natural populations of bacteria, a few individuals may carry genes that make them resistant to antibiotics. These genes arise from mutations. When exposed to antibiotics, these resistant bacteria have a selective advantage; they are more likely to survive and reproduce than non-resistant bacteria and pass on their resistance to their offspring. This is causing increasing numbers of resistant bacteria to appear within populations. **(4 marks)**

c) Natural selection is a process occurring in nature in which organisms possessing advantageous characteristics tend to survive, reproduce and pass on these advantageous characteristics to their offspring, causing species to constantly change and evolve over time. For example, the melanic variety of the peppered moth in industrial areas of Britain, the thirteen different varieties of finches on the Galapagos Islands and the different species of anole lizards on Cuba, Hispaniola, Jamaica and Puerto Rico all evolved as a result of natural selection. (Other suitable examples may be given.)

Artificial selection involves humans selecting and breeding organisms showing desirable characteristics to suit human needs. Jamaica Hope cattle have been bred in Jamaica to be heat tolerant, have a high resistance to ticks and tick-borne diseases, and produce a high yield of milk. Sugarcane has been bred to produce varieties with a high sucrose content, increased resistance to disease and insect pests, greater suitability to its environment and improved ratooning ability. (Other suitable examples may be given.)

(4 marks)

Total 15 marks