

Model Answers

CHAPTER 1 INTRODUCTION TO BIOLOGY AND LABORATORY RULES

Formative Practice 1.1

- 1 Biology is the study of life and interactions of living things with their environment.
- 2 Genetics (bioinformatics), microbiology (various vaccines and medicine), biotechnology (bioplastics).
- 3 Biotechnology. Bioplastics can be produced from agricultural by-products, or from used plastic bottles by using microorganisms.
- 4 Wildlife biologists, doctors, chiropractors, exercise physiologists, microbiologists, marine biologists, botanists.

Formative Practice 1.2

- 1 (a) Eye goggles – to protect eyes from dangerous chemicals.
(b) Lab coat – to protect clothes from damage.
(c) Fume chamber – to prevent inhalation of dangerous gases such as chlorine, bromine and nitrogen dioxide.
- 2 Category B biological waste must be packed in autoclave resistant biohazard plastic bags, sterilised in the autoclave to be decontaminated, and later placed into a biohazard bin. Biohazard plastic bags must not be disposed in normal bins.
- 3 (a) Inform your teacher.
(b) Restrict the spill area.
(c) Sprinkle sulphur powder to cover the mercury spill.
(d) Call the fire brigade.
- 4 (a) Be careful when handling hot glass apparatus.
(b) Report any damaged apparatus or glassware to the teacher immediately.

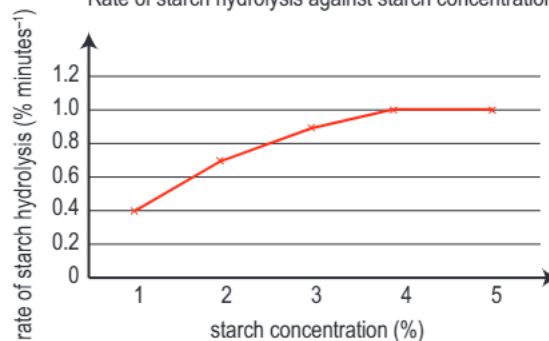
- (c) Keep flammable chemicals away from fire sources.
- (d) Do not touch, smell, or taste chemical substances directly.

Formative Practice 1.3

- 1 (a) Manipulated variable: starch concentration.
Responding variable: duration for complete starch hydrolysis / rate of starch hydrolysis.

(b)

Rate of starch hydrolysis against starch concentration



- 2 (Any five)
 - Large and accurate; use a sharp pencil and not a coloured pencil or a pen.
 - Do not shade artistically.
 - Lines must be drawn clearly, continuously, and not disconnected. Do not use a ruler to draw specimen outlines.
 - Drawings must be labelled. Label lines must be point to the right structure, must not have an arrowhead, must be straight and do not cross each other.
 - Drawings must be titled.
 - Every structure in a drawing must be put in the correct position and its size must be proportionate to other structures.
- 3 Three main planes that are used are frontal plane, sagittal plane and horizontal plane.
 - (a) Identifying a problem that can be tested with a scientific investigation.

- (b) Building a hypothesis.
- (c) Identifying and controlling variables as well as the data collection method.
- (d) Planning and carrying out a scientific investigation.
- (e) Collecting data.
- (f) Interpreting data and results through scientific reasoning.
- (g) Making a conclusion.
- (h) Writing a report.

Summative Practice 1

- 1 To avoid injuries to legs and feet from broken glass and chemical spills.
- 2 (a) Cross section divides a structure horizontally into upper and lower portions.
(b) Longitudinal section divides a structure into left and right.
- 3
 - Category A (sharp wastes): Sharp instruments such as syringes, needles, glass and scalpel. These are placed in a special bin for sharp items. This bin does not need to be sterilised.
 - Category B (non-sharp wastes): Solid biological wastes such as gloves, tissue paper, petri dish, plastic culture containers and hardened agar. Packed in autoclave resistant biohazard
 - plastic bags, sterilised in the autoclave to be decontaminated, and later placed into a biohazard bin. Biohazard plastic bags must not be disposed off in normal bins.
 - Category C (animal carcass): Carcasses, organs, and tissues of laboratory or experimental animals. Wrapped in absorbent material (such as tissue paper), packed neatly into biohazard plastic bags and is frozen.
 - Category D (fluids): Broth culture, liquid medium such as blood and/or blood products. All biological liquid wastes must be decontaminated

using the autoclave before disposal. Sterilised biological liquid wastes must be disposed off immediately.

- 4 Steps of scientific investigation:
 - Identifying the problem – Determining the problem that will be investigated.
 - Making a hypothesis – Presenting a statement that will be tested through an experiment for its validity.
 - Planning the investigation – Collecting information or scientific background about an experiment, selecting and preparing materials, apparatus as well as the right method.
 - Controlling variables – Determining the fixed variables, manipulated variables and responding variables.
 - Carrying out the investigation – Correct usage of instruments, apparatus, and materials correctly, observation(s) is/are done meticulously, cleaning and storage of instruments and apparatus after the experiment, as well as correct disposal of waste materials.
 - Collecting data – Data or observation recorded efficiently, systematically with various methods.
 - Analysing data – Data is converted into a more meaningful form, such as a graph.
 - The relationship between the responding variable and the manipulated variable is determined.
 - Data interpretation – Data is interpreted logically and objectively. The information obtained is then described clearly into smaller parts to find the relationship or connection between the parts of information or data collected.
 - Making a conclusion – Hypothesis is accepted or rejected and a conclusion is derived from the experiment.
 - Making a report – A report is written based on the steps of the scientific method.
- 5 (a) (i) How does the presence of amylase enzyme affect starch hydrolysis?

- (ii) Starch can be hydrolysed in the presence of amylase enzyme compared to without the presence of amylase enzyme.
- (iii) Manipulated variable: presence of amylase enzyme
Responding variable: starch hydrolysis
Fixed variables: time and temperature
- (b) The pupil must inform the teacher/lab assistant as soon as possible and restrict access to the spill area (stop other pupils from coming near the spill area).

Essay Questions

- 6 (a)
- Make sure the victim does not run around and instruct him/her to lie down.
 - Use a fire blanket to put out the fire once the victim lies down.
 - If there is no fire blanket, roll the victim on the floor.
 - Inform the teacher or lab assistant as quickly as possible so the victim can get immediate treatment.
 - The fire alarm should be activated at once.
- (b)
- Immediately inform the teacher or lab assistant.
 - Use sulphur powder to cover the mercury spill.
 - Restrict the spill area to prevent further accidents.
 - Report the accident to the fire brigade and rescue team.
- (c) To study the effect of sugar on the growth of yeast (EXPERIMENT)

Problem statement:

What is the effect of sugar on the time taken for the dough to double in size?

Hypothesis:

The time it takes for the dough to double in size is shorter with the presence of sugar.

Variables:

Manipulated variable:

Presence of sugar

Responding variable:

The time it takes for the dough to double its size

Fixed variables:

Amount of flour, yeast and water used, water temperature, and time taken to knead the dough

Materials:

1.5 g yeast, 5 g glucose, 100 ml lukewarm water, cloth and 170 g flour

Apparatus:

1000 ml beaker, 250 ml conical flask, mixing bowl and stopwatch

Procedure:

1. Mix the glucose with a little bit of lukewarm water in a conical flask.
2. Dissolve the yeast in the glucose mixture.
3. Leave the yeast suspension for 20 minutes. This is to ensure the yeast is activated and grows.
4. Put half of the flour in the mixing bowl.
5. Once the yeast mixture has expanded and bubbles, make a hole in the middle of your mixing bowl and pour in the yeast mixture.
6. Mix the mixture well to make a soft dough.
7. Add the rest of the flour gradually until it becomes difficult to mix the dough.
8. Sprinkle some flour on the table surface and put the dough on it.
9. Knead the dough for 10 minutes until it becomes smooth, elastic and not sticky.
10. Knead the dough by folding it and pressing it downwards with your palms. Squeeze the dough and fold and press the dough repeatedly.

11. Put the dough in a 1000 ml beaker. Press the dough down and record its volume.
12. Cover the beaker with a clean cloth and put it in a place with moderate temperature.
13. Start the stopwatch and record the time it takes for the dough to double in size.
14. Repeat the whole procedure to prepare the second dough using the same materials but without adding glucose.
15. Write a report regarding the experiment.

Results:

Dough	Time taken for dough to double in size or volume (minute)
Dough with glucose	
Dough without glucose	

Enrichment

- 7** Some of the effects of Industrial Revolution 4.0 on daily life
- Artificial Intelligence or A.I. Through A.I., a system is created to study the environment and enhance the relationship between humans, physical equipment and the digital world.
 - Cloud Processing Technology in storage and processing of data, that connects smart senses to equipment via internet connection,

Cybersecurity to protect data and minimise risks, and 3D printing that eases prototype development.

- Automated Robotic Technology is able to operate in a working environment that is similar to humans.
- Virtual Reality can provide information virtually, Intermediate Reality can combine the physical and virtual worlds, and Big Data Analytics uses data collected for service provision and more accurate projections.

- 8** (a) The first step is to get information about tissue culture technique. This can be done by:
- Surfing the internet
 - Referencing printed materials such as journals or electronic references
 - Visiting local universities or research institutions to obtain the information needed.
- (b) From the information obtained, data regarding the production of a new plant from a chosen cell, for example an orchid plant, can be collected.
- (c) A report is prepared. The report contains the method of planting using tissue culture along with interesting graphics and a discussion on how the technique is carried out. Current issues regarding the technique can also be discussed.
- (d) At the end of the report, conclusion is made regarding tissue culture technique.

Model Answers

CHAPTER 2 CELL BIOLOGY AND ORGANIZATION

Formative Practice 2.1

- 1 Rough endoplasmic reticulum has ribosomes attached to it whereas smooth endoplasmic reticulum does not have any ribosomes attached to it.
- 2 Light microscope usually has a magnification of 1000x. On the other hand, the electron microscope is able to magnify a cell as much as 2000000x. Without an electron microscope, cell structures cannot be seen clearly because the light microscopes can only observe certain cell components, such as cell membrane, cell wall, nucleus, cytoplasm, and chloroplast only.
- 3 Onion cell because onions grow in the ground. Onions obtain food from their storage organs which are onion bulbs.
- 4 Similarities:
Both cells have nucleus, cytoplasm, plasma membrane, Golgi apparatus, mitochondria, endoplasmic reticulum and ribosomes.

Differences:

- Plant cells have a fixed cell shape whereas animal cells do not have.
- Plant cells have cell walls whereas animal cells do not.
- Plant cells have chloroplasts whereas animal cells do not.
- Plant cells have large vacuoles, whereas animal cells do not (if there is, the size is small).
- Plant cells do not have centrioles whereas animal cells do.

Formative Practice 2.2

- 1 Contractile vacuoles are involved in osmoregulation.
- 2 *Amoeba* sp. moves by extending its pseudopodium (false feet). This is followed by cytoplasmic streaming into the extended pseudopodium.

- 3 *Amoeba* sp. forms spores. In the spores, mitosis takes place multiple times to form daughter cells. Once environmental conditions improve, the spores will germinate and release daughter cells.
- 4 The contracting rate of the contractile vacuole will decrease.

Formative Practice 2.3

- 1 Rough endoplasmic reticulum, ribosomes and Golgi apparatus.
- 2 A nerve tissue is made of cell body and nerve fibres that are called dendrites and axons. Nerve tissues coordinate and control bodily activities.
- 3 A large number of chloroplasts can absorb more light for photosynthesis.
- 4 Fat cells contain very little cytoplasm but have high fat content.
Fat cells contain very few mitochondria because it does not need a lot of energy.
Fat cells can expand to store more fat.

Formative Practice 2.4

- 1 Cell → Tissue → Organ → System
→ Multicellular organism
- 2 Skin is classified as an organ because skin is made up of epithelial tissues, connective tissues, nerve tissues and muscle tissues that work together to carry out the functions of skin.
- 3 Trunk and branches make up the support system of plants to support leaves at a vertical position to allow maximum absorption of sunlight during photosynthesis. Flowers are involved in reproduction.
- 4 The organism is not able to carry out a lot of functions that are needed for its survival.

Summative Practice 2

- 1 This is because chloroplast is used to produce food during photosynthesis. Animal cells do not produce food.

- 2 *Amoeba* sp. undergoes binary fission. When *Amoeba* sp. has expanded to a certain size, the nucleus will divide mitotically. Then, cytokinesis takes place. Two *Amoeba* sp. that possesses the same genetic composition are formed.
- 3 Phloem sap. Photosynthesis takes place during the day. Therefore more sugar is produced and is absorbed by the aphid.
- 4 P is cell wall. P is built from cellulose which is strong and fibrous as well as fully permeable. The function of cell wall is to maintain plant cell shape.
- 5 X is stomach. The rough endoplasmic reticulum carries proteins produced by ribosomes. Stomach is an organ that synthesises enzymes in large amounts for protein breakdown.
- 6 Process X is differentiation. Xylem forms hollow connected tubes. This ensures the continuous transport of water and mineral salts.
- 7 Herbicides contains respiratory poisons. Herbicides will destroy respiratory enzymes that will stop cellular respiration. No ATPs are produced, which then hinders the active transportation of ions into plant cells.
- 8 Through osmoregulation. Osmoregulation in *Amoeba* sp. involves contractile vacuoles. Water will be absorbed into *Amoeba* sp. via osmosis. Water collects in the contractile vacuoles until they reach the maximum size. Then, the contractile vacuoles will contract to expel water from *Amoeba* sp. As such, *Amoeba* sp. does not overexpand and burst.
- 9 (a) (i) K – Golgi apparatus
(ii) K – The centre for processing, packaging and transportation of carbohydrate, protein and glycoprotein
N – Contains chlorophyll to trap sunlight for photosynthesis
- (b) • L is vacuole. Cell sap inside the vacuole contains water, dissolved substances and mineral salts.
- When water enters the vacuole, the vacuole expands.
- The vacuole and cytoplasm will push towards the plasma membrane and cell wall. This will produce turgor pressure within the cell and maintain cell turgidity.
- 10 (a) • The meristematic tissue is a tissue that has small cells, compact cytoplasm and many nuclei. This tissue carries out cell division.
- The epidermal tissue has cells with large vacuoles and a thin layer of cytoplasm. This tissue covers the surface of plants to protect it from injury and loss of water.
- (b) Cell is the basic unit of all life. Tissue is a group of cells that have a certain structure and carry out a certain function.
- (c) The epithelial tissue is made up of one or more layers of cells that cover the surface or body cavity and protects it from injury and drying up. The muscle tissue is made up of muscle cells and muscle fibres that can contract and relax to produce movement.
- 11 (a) P: Mesophyll cell R: Epidermal cell
- (b) P contains a large number of chloroplasts for maximum absorption of sunlight for photosynthesis. R protects plant tissues from mechanical injury.
- (c) When light intensity and carbon dioxide concentration are high, guard cells (Q cell) curve outwards. This causes the stomata to open and allow more carbon dioxide to enter the leaves.
- (d) (i) Xylem and phloem
- (ii) • Xylem is made up of vessel elements and tracheids that are connected from one end to the other.
- Vessel elements do not contain any cytoplasm.
- The cell walls are impregnated with lignin.

- These characteristics allow xylem to transport water and mineral salts throughout the entire plant.
- Phloem consists of sieve tubes that are arranged from one end to the other end. Sieve tubes contain sieve plates that allow the continuous transportation of organic compounds.

Essay Questions

- 12** Example of unicellular organism is *Amoeba* sp. Five life processes of unicellular organisms are as follows:
- Movement
Amoeba sp. extends its pseudopodium through the flow of cytoplasm to move.
 - Nutrition
Ingests through phagocytosis by extending its pseudopodium to engulf food particles. Food is kept inside food vacuoles and hydrolysed by enzymes before being absorbed.
 - Respiration
Gaseous exchange of oxygen and carbon dioxide through plasma membrane by diffusion.
 - Excretion
Excretory products such as carbon dioxide and ammonia are excreted via diffusion. Cellular osmotic pressure is controlled by contractile vacuoles.
 - Reproduction
Reproduces via asexual reproduction, which is binary fission and spore formation.
- 13** (a) • X is the contractile vacuole that controls the water content in a unicellular organism.
- Excess water within the cell will enter the contractile vacuole through osmosis.
 - This will cause contractile vacuole to expand.
 - The vacuole will then contract to expel water from the organism.

- (b) If a cell does not have Golgi apparatus, protein from rough endoplasmic reticulum:
- will not be processed and modified
 - will not be separated according to their respective destinations
 - will not be packaged into vesicles

Thus, protein cannot be transported to other parts of the cell or secreted by the cell as extracellular enzymes.

- (c) (i) • Cell P is root hair cell.
- Root hair cells are normal epidermal cells with long projections.
 - This allows the root hair to seep between soil particles to reach water that surrounds soil particles.
 - Long and thin projections increase the total surface area of the cell to absorb water and mineral salts. The thin and semipermeable plasma membrane allows water to diffuse through it into the cytoplasm via osmosis.
- (ii) • Q is a red blood cell. The red blood cell does not have a nucleus. It is shaped like a biconcave disc and flat.
- This increases the cell's total surface area and allows oxygen to diffuse faster into the cell.
 - Red blood cells are elastic. This allows the cells to move through very thin capillaries.
 - Red blood cells also contain a red pigment known as haemoglobin that transports oxygen throughout the entire body.

Enrichment

- 14** • The epithelial tissue that lines the lungs, colon or the skin is the outermost layer of the skin or of the organ. As such, the epithelial tissue is the first tissue to be exposed to any substances that can cause cancer compared to other tissues.

- The second factor is the high rate of cell division in epithelial cells, which means mutations are more likely to happen spontaneously due to an error during DNA replication.
- Both factors contribute to the higher chances of cancer occurring in the epithelial tissue.

15 Cells of new cartilage tissue can be generated through embryonic stem cell injections to parts of the damaged cartilage discs. Visit <https://www.regenexx.com/stem-cell-disc-treatment/> to see how this procedure is carried out.

Model Answers

CHAPTER 3 MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE

Formative Practice 3.1

- 1 Proteins and phospholipids
- 2 The fluid mosaic model refers to protein molecules that are suspended in the phospholipid bilayer forming an ever-changing mosaic pattern. The phospholipid bilayer, proteins and cholesterol are not static but form a dynamic and flexible structure.
- 3 Without cholesterol, the plasma membrane will become too fluid at normal body temperature and may rupture. Without cholesterol, the membrane will become too permeable to dissolved substances.
- 4 The characteristic of phospholipid and protein molecules that only allow passage for a certain number of substances enables or limits the free movement of certain substances through the plasma membrane. This characteristic determines the selective permeability of the plasma membrane.

Formative Practice 3.2

- 1 Oxygen, carbon dioxide, water.
- 2 Three sodium ions bind to the carrier protein. The ATP molecule is broken down to ADP and P. The phosphate group binds to the carrier protein. The phosphate bond provides energy and changes the shape of the carrier protein, which then transports the sodium ions out through the carrier protein.
- 3 The uptake of mineral salt ions by plant roots is through active transport and involves the usage of energy. More energy is generated when root cells carry out more cellular respiration using oxygen. As such, the concentration of mineral salt ions in the root increases when the concentration of oxygen in the soil increases by 10%.

Formative Practice 3.3

- 1 (a) Red blood cells undergo crenation.
(b) Plant cells undergo plasmolysis.
- 2 When red blood cells are put into a hypotonic solution, water is absorbed into the cell via osmosis, causing the cell to expand and eventually burst. The rupture of red blood cells is known as haemolysis.
- 3 When the plant cell sap and its external solution are isotonic, the values of the water potential are the same. Water movement in and out of the cell is the same. The cell becomes flaccid.
- 4 (a) Water diffuses into vegetable cells and fruit cells via osmosis causing the vacuole to expand. Cell sap within the vacuole pushes the cytoplasm and plasma membrane towards the cell wall, causing the vegetable cells and fruit cells to become turgid again.
(b) The external environment becomes hypertonic compared to the cell sap within the strawberry cells. This causes water to diffuse out of the strawberry via osmosis.

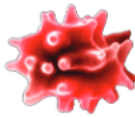
Formative Practice 3.4

- 1 The concentrated sugar solution is hypertonic to the cell sap of chili. Water diffuses out of the chili via osmosis. The chili undergoes dehydration. Bacteria is unable to survive without water. Thus, pickled green chili can be kept for a long time. Vinegar reduces pH. Bacteria also cannot live in an acidic environment.
- 2 Two advantages:
 - Prevents wastage due to spoilage.
 - Preserved pineapples last longer.Two disadvantages:
 - Pineapples contain too much sugar.
 - Nutrients are damaged by oxidation during preparation. This causes the preserved pineapple pieces to have low nutrients.

- 3 Ariana can take rehydration drinks such as oral rehydrating salts. Ingestion of this drink can replace the water and electrolytes lost due to diarrhoea.
- 4 Liposomes are used to protect medicine or active substances that are eaten orally from being destroyed by gastric juices. This way, the medicine can reach target cells effectively.

Summative Practice 3

- 1 Molecules or ions move along concentration gradient and do not need energy.
- 2 Most molecules dissolve in water and do not dissolve in lipid. As such, these molecules do not move through the phospholipid bilayer. Some molecules that are too large (such as glucose molecules) and sodium ions cannot move through the phospholipid bilayer. Ions such as sodium ions cannot move through the phospholipid tail.
- 3
 - The concentrated sugar solution is a hypertonic solution. This causes water within the food cell to diffuse out of the food via osmosis.
 - The food becomes dehydrated. The absence of water in the food allows the food cells to last longer because microorganisms cannot survive without water.
- 4 (a) Water diffuses into the contractile vacuole. The vacuole then expands to its maximum size. The vacuole will then move to the cell membrane. At the cell membrane, the contractile vacuole will contract and expel water from *Amoeba* sp. to the environment. This prevents the organism from bursting.
- (b) *Amoeba* sp. shrinks. Seawater is hypertonic to the fluid in *Amoeba* sp. Water diffuses out of contractile vacuoles through osmosis. *Amoeba* sp. dies.
- 5 (a) (i) Plasma membrane.
(ii) X: phospholipid bilayer. Y: carrier protein
- (b) The plasma membrane will be pushed against the cell wall. Distilled water is hypotonic to the plant cell sap. Water molecules diffuse into the cell via osmosis. The vacuole will expand.
- 6
 - The ion movement is against the concentration gradient.
 - The carrier protein binds with a calcium ion.
 - ATP provides energy to the carrier protein.
 - The energized carrier protein changes shape and the calcium ion is transported through the carrier protein out of the cell.
- 7 (a) A sediment forms at the bottom of test tube A and C whereas the whole solution in test tube B looks pink.
- (b)
 - For test tube A, the 4.5% sodium chloride solution is hypertonic to red blood cells. Water will diffuse out of the cells via osmosis causing the cells to shrink (cells undergo crenation) and settle at the bottom of the test tube.
 - For test tube B, distilled water is hypotonic to red blood cells. Water will diffuse into the cells via osmosis causing the cells to expand, burst and release the red pigment, haemoglobin and cell contents into the solution (cells undergo haemolysis).
 - The red pigment causes the solution to appear pink.
- (c)



Hypertonic
(Test tube A)



Hypotonic
(Test tube B)



Isotonic
(Test tube C)
- (d) The 0.85% sodium chloride solution because this solution is isotonic to red blood cells. Cells do not change shape and maintain their biconcave shape.

Essay Questions

8 Similarities:

- Does not need metabolism energy.
- Occurs until an equilibrium is achieved, that is, when all the molecules are evenly distributed everywhere.
- Occurs when there is a difference in concentration or concentration gradient.

Differences:

- Simple diffusion that involves the movement of any molecules whereas osmosis involves the movement of water molecules.
- Simple diffusion does not need take place through a selectively permeable membrane whereas osmosis takes place through a selectively permeable membrane.

- 9 (a) (i) • Vegetables that are soaked too long in a salt solution will wilt because the salt solution which is hypertonic to the cell sap of vegetables, causes water to diffuse out of cells via osmosis.
- Plant cells undergo plasmolysis.
 - The vegetables wilt.
- (ii) • To regain turgidity, the vegetables must be soaked in water.
- The water in the external environment will diffuse back into the vegetable cells and cell turgidity is restored.
- (b) • Amino acid molecules are transported across the plasma membrane via facilitated diffusion.
- Amino acid molecules are transported from a high concentration area to a low concentration area, along the concentration gradient with the help of carrier proteins.
 - Amino acid molecules will move towards carrier proteins and bind with the carrier protein's specific site.
 - The carrier protein changes shape to allow the amino acid molecules to pass through the carrier proteins into the cell.

- After that, carrier proteins will return to their original state and prepare to transport more amino acid molecules.

- (c) • Liposome is a vesicle that contains aqueous solution encased in a membrane made up of phospholipids.
- Liposome is used to transport active substances in cosmetics into the epidermal layer of the skin.
 - The liposome transports active substances in skincare cream to the lower epidermal layer so that the active substance can be more effective.
 - Without liposomes, active substances within skincare cream, for example vitamin C, will be easily oxidised.

Enrichment

10

	Carbohydrate content	Justification
Gymnast	1–3% Hypotonic solution	To hydrate the body and replace water lost through perspiration. Only needs a small amount of extra carbohydrates to provide energy.
Moderate distance runner	6–8% Isotonic solution	To replace water lost through perspiration as well as to provide some energy for the athlete.
Football player	10–12% Hypertonic solution	To provide instant energy because of the high usage of energy during training. Suitable to be taken after activities to replenish the glycogen storage in muscles.

- 11** (a) • An example of substance P is vitamin A/fatty acid/glycerol/steroid.
- Graph shows that when the concentration of substance P increases, the rate of movement for substance P through plasma membrane also increases.
 - Substance P moves through plasma membrane using simple diffusion.
 - The movement of substance P is along the concentration gradient.
 - Substance P dissolves in lipid and moves through the phospholipid bilayer freely.
- (b) Similarities:
- Both substances P and S move along the concentration gradient.
 - Both move without energy.

Differences:

- The graph in Figure 4 shows that the rate of movement of substance S increases until it reaches a certain concentration level and became constant, whereas the graph in Figure 3 shows that the rate of movement of substance P increases proportionately with an increase in the concentration of P.
- Substance S needs carrier proteins whereas substance P do not need carrier proteins to move across the plasma membrane.
- Molecule P is lipid-soluble whereas molecule S is not lipid-soluble.
- Substance P moves via simple diffusion whereas substance S moves via facilitated diffusion.

Model Answers

CHAPTER 4 CHEMICAL COMPOSITION IN A CELL

Formative Practice 4.1

- 1 Hydrogen bond
- 2 Water is known as a polar molecule because oxygen atoms are more electronegative compared to hydrogen atoms which causes the electrons shared between them to become more attracted to the oxygen atom. This causes the oxygen atom end to have a partially negative charge and the hydrogen atom end have a partially positive charge.
- 3 Water adhesion refers to the ability of water molecules to stick to another surface whereas water cohesion refers to the ability of water molecules to stick to each other.
- 4 When the body sweats, the condensation of sweat from the surface of our skin will use heat energy from our body, which then cools our body.

Formative Practice 4.2

- 1 Carbon, hydrogen and oxygen.
- 2 Monosaccharide, disaccharide and polysaccharide.
- 3 Examples of reducing sugars are glucose, galactose, fructose, maltose and lactose. Non-reducing sugar is sucrose.
- 4 Sucrose is a non-reducing sugar because it cannot reduce copper (II) sulphate to copper (I) oxide.

Formative Practice 4.3

- 1 Amino acids.
- 2 Condensation.
- 3 (Any two)
 - Build new cells
 - Repair damaged tissues

- Synthesise enzymes, hormones, antibodies and haemoglobin

- 4 Hair fall, soft and brittle nails

Formative Practice 4.4

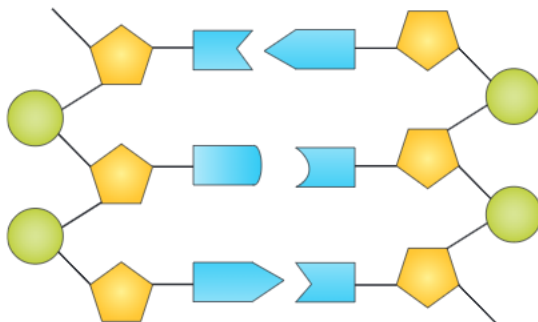
- 1 Carbon, hydrogen and oxygen. Some lipids contain phosphorus and nitrogen.
- 2 Fat, phospholipid, wax and steroid.
- 3 Although synthetic steroid can help in building muscles, steroid intake can lead to side effects such as increase in blood pressure, infertility and risk of stroke. This is why synthetic steroid intake should be avoided.

Formative Practice 4.5

- 1 Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- 2 Components in nucleotides are phosphate group, nitrogenous base and pentose sugar.
- 3 RNA is shorter because RNA is produced from a small part of DNA called a gene.
- 4 If there is no nucleic acid, cells cannot transfer inheritance information, which determine the characteristics in living organisms, from one generation to the next. Cells will also eventually die because they are unable to produce important proteins for their survival.

Summative Practice 4

- 1 Functions of wax:
 - Prevent water loss from fruits
 - Maintain the freshness of fruits
 - Delay the decomposition process in fruits
- 2 (a) P: phosphate group. Q: nitrogenous base. R: pentose sugar



- 3 (a) DNA molecules is made up of two polynucleotide chains that consist of nucleotides each whereas the polypeptide chain consists of amino acids.
- (b) DNA consists of two polynucleotide chains whereas RNA consists of one nucleotide chain.
- 4 (a) • Water dissolves oxygen and carbon dioxide to be transported in blood.
• Water dissolves digested food such as glucose and amino acids in blood plasma to be transported throughout the body where it is needed.
- (b) Ice which is less dense than water is able to float on water and trap heat. This characteristic allows aquatic organisms to survive in ice-covered water.
- 5 (a) K: Glycerol. L: Fatty acid. M: Triglycerides
P: Condensation. Q: Hydrolysis
- (b) Differences between unsaturated and saturated fat

Saturated fat	Unsaturated fat
Only single bonds between carbons in the fatty acid chain	At least one double bond in fatty acid chain
Does not form chemical bond with additional hydrogen atoms because all the bonds between carbon atoms are saturated	Double bonds can still accept one or more hydrogen atoms

Solid form at room temperature	Liquid form at room temperature
Source: butter and animal fat	Source: vegetable oils such as olive oil and fish oil

Essay Questions

- 6 (a) Organic macromolecule compounds are large and complex compounds that contain carbon elements. Most macromolecules are polymers that consists of small molecules known as monomers.
- (b) Polysaccharides are formed through the process of condensation and involves hundreds of monosaccharides that form long molecular chains.
- (c) The primary organic compounds are carbohydrates, proteins, lipids and nucleic acids. The importance of these compounds are as follows:
- Carbohydrates
 - Main source of energy in a cell
 - Stored in the form of starch and glycogen
 - Supports cell in the form of cellulose and chitin
 - Proteins
 - As much as 15% of protoplasm is made up of proteins.
 - Forms part of the plasma membrane structure.
 - Lipids
 - Forms 15% of protoplasm.
 - Is a main component of the plasma membrane which is phospholipid.
 - Is a main component in hormones such as oestrogen and progesterone.
 - Nucleic acids
 - Maintains genetic information from generation to generation.

- Used as a template in RNA production and later in protein production by RNA.
- Forms part of the enzymes for digestion.

Enrichment

- 7 Soak cut potatoes in ice for a long period of time to remove as much as possible the starch from the potatoes before cooking.
- 8 Seaweed pulp is a suitable substance that can be used as a separating layer in batteries. This is because it has a high absorption rate. The main component of the pulp is cellulose which is a polymer of carbohydrate.

Model Answers

CHAPTER 5 METABOLISM AND ENZYMES

Formative Practice 5.1

- 1 Trypsin is not synthesised therefore protein digestion is slower.
- 2 This is because the optimal temperature of enzymes is 37 °C.
- 3 pH 1.5–2.5
- 4 Sucrase

Formative Practice 5.2

- 1 Enzymes are extracted from natural resources such as bacteria or are produced synthetically in factories.
- 2 Through the immobilized enzyme technology, enzymes are attached to inert materials that enables increased resistance to changes in factors such as temperature and pH and this allows the enzymes to react at a maximum rate.
- 3 Immobilised enzyme technology is used in industries that produce high-fructose corn syrup, pectin hydrolysis and biodiesel.

Summative Practice 5

- 1 To tenderise meat.
- 2 Apples contain a type of enzyme that transforms the colour of apple tissue to brown after it is peeled and left for a while. If the apple is boiled, the enzyme becomes denatured causing the apple to not turn brown.
- 3 (a) Cellulase breaks down the cell wall of seaweed and separates the agar-agar from it.
(b) Lipase is used in the production of cheese.
- 4 (a) Enzyme reactions are specific. The enzyme's active site does not change shape once the reaction is completed.

- (b) The structure of the substrate molecule matches the structure of the enzyme molecule which allows them to bind together. Other substrate molecules that do not have the structure that matches the enzyme molecule will not be able to bind to it.
- (c) (i) Lock and key hypothesis. Enzyme is represented by the lock while substrate is represented by the key.
(ii) The enzyme reaction is specific, where only one type of enzyme can react with a certain type of substrate.

Essay Questions

- 5 (a) The enzyme that is used in meat processing is protease. Protease helps to tenderise meat. The enzyme that is used in fish processing is protease. Proteases can separate fish meat from its skin.
(b) Enzyme is an organic catalyst that accelerates the rate of chemical reactions in living organisms.

Characteristics of enzyme that affect its reactions:

- (i) Enzyme is very sensitive to temperature. Each enzyme functions optimally within a certain temperature range. At temperatures too high, the protein structure in the enzyme will be denatured whereas at temperatures too low, the enzyme becomes less active.
- (ii) Enzyme is sensitive to changes in pH. Each enzyme functions optimally within a certain range of pH value. If the pH value is not within the optimum range, the enzyme will become inactive. For example, pepsin reacts in the pH range of 1.5 to 2.
- (iii) Enzymes are specific. Only substrate molecules that can complement the enzyme molecule will bind to it so that reaction can take place.

Enrichment

- 6 The washing machine has a temperature control function. High temperatures can cause the enzymes in detergents to denature. Thus, if enzymes are extracted from live bacteria in hot springs, these enzymes are able to withstand high temperatures without denaturing.
- 7 Cyanide can bind with one of the cellular respiration enzymes. Cyanide can block glucose oxidation and stop cellular respiration. Without cellular respiration, a person will die.
- 8 Experiment:
 - A few apples are blended together.
 - The blended apple mixture is divided equally into two different beakers, beaker A and beaker B.
 - The blended apple mixture is left at room temperature for 30 minutes to allow the enzyme inhibitor that exists naturally in the apples to be oxidised to its inactive form.
 - 2 ml of distilled water is added to beaker A while 2 ml of pectinase solution (enzyme solution containing cellulose and hemicellulose) is added to beaker B (pectinase is diluted with distilled water to a 50% concentration before added to beaker A).
 - Both beakers are immersed in water at 30 °C for 30 minutes.
 - The solution from both beakers are then filtered into two different measuring cylinders.
 - The apple juice obtained from beaker B is 20% more than beaker A.

Model Answers

CHAPTER 6 CELL DIVISION

Formative Practice 6.1

- (a) Karyokinesis is a stage in cell division that involves the division of nucleus.
(b) Cytokinesis is the cytoplasm division stage.
(c) Chromatin is double-stranded DNA that is coiled around histone proteins.
(d) Homologous chromosomes is a pair of chromosomes from the same set of chromosomes, with one chromosome from male parent and the other from female parent.
- The resulting zygote will have 92 chromosomes ($46 + 46$), which is double that of the parent's chromosomes. If this happens, the zygote produced will degenerate by itself.

Formative Practice 6.2

- Mitosis is used in plant tissue culture to produce plantlets from a parent cell.
- In phase S, DNA content will double, that is, DNA replication.
- Sister chromatids will not separate. One daughter nucleus will contain more than one chromosome.
- For embryonic development and organism growth, mitosis ensures rapid cell multiplication.
 - When our body is injured, mitosis will produce new cells to replace dead or damaged cells.
 - Through mitosis, the lizard is able to grow a new tail (regeneration) if it falls off.
 - Mitosis helps organisms such as hydra to produce new individuals through bud formation.

Formative Practice 6.3

- The most obvious difference between meiosis I and meiosis II is the decrease in number of chromosomes in the cell.

- Meiosis I reduces the number of chromosomes in daughter cells when homologous chromosomes separate in anaphase I.

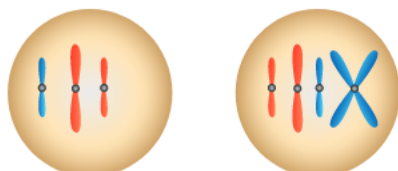
Formative Practice 6.4

- Radiotherapy (RT) is a method used to treat cancer. This method uses high-powered ionising radiation to kill cancer cells. A high dose administration is administered to the target (tumor) to heal, control or reduce symptoms of the patient. However, adjacent parts may also be exposed to radiation which can lead to side effects.
- An individual with Down syndrome has 47 chromosomes. This syndrome can cause intellectual disability, slanted eyes and a protruding tongue.

Summative Practice 6

- Prophase, metaphase, anaphase, telophase
- To form spindle fibres
- At the mitotic metaphase stage, chromosomes are arranged on the equatorial plane whereas in metaphase I, homologous chromosomes are arranged at equatorial plane.
 - At the mitotic metaphase stage, each chromatid is tied to spindle fibres at the centromere whereas at the metaphase I stage, one chromosome from each pair of homologous chromosomes is tied to the spindle fibres from one pole and the other is tied to the spindle fibres from the opposite pole.
- (a) Cells divide actively through mitosis to produce more cells. The high number of cells elongates the roots so that it can absorb more water and mineral salts to support plant growth.
(b)
 - Technique: tissue culture
 - Explants are placed in a sterile culture medium that contains nutrients and growth hormones.

- Explants divide mitotically to form callus. This callus then forms embryo/plantlets.



Essay Questions

- 6 (a) Down syndrome
- (b) Homologous chromosome 21 fail to separate due to non-disjunction that happens at anaphase I. Spindle fibres fail to form.
- 7 (a) Cancer cells form when there is mutation in the DNA of a normal cell. This causes mitotic cell divisions to happen rapidly and without control.

- (b) High-powered ionising rays such as X-rays and gamma rays. Carcinogens such as benzene and carbon tetrachloride.
- (c) Avoid exposure to radioactive rays.
- (d) Avoid eating food that contains carcinogens.

Enrichment

- 8 RNA interference is a natural cell mechanism that functions to stop gene activity. This mechanism indirectly affects protein formation. Living organisms have this mechanism as a defence mechanism against viral attacks. The RNA interference technology applies this knowledge by producing specific RNAs to stop specific gene activity. This technology is not only limited to orchid plants but theoretically, can also be used for all types of organisms.

Model Answers

CHAPTER 7 CELLULAR RESPIRATION

Formative Practice 7.1

- 1 • Maintaining body temperature at the optimal temperature of 37 °C.
• Muscle contractions to enable movement.
• Cell division whereby new cells are produced for growth and development.
• Absorption of digested food through active transport.
• Synthesis of lipids, hormones, proteins and enzymes.
- 2 Carbohydrate (glucose).
- 3 Cellular respiration is the oxidation process of organic molecules through a few stages to release energy. The main substrate for cellular respiration is glucose. There are two types of cellular respiration: aerobic respiration and anaerobic respiration.
- 4 In humans and animals, glucose is obtained through the breakdown of carbohydrates whereas in plants, glucose is produced through photosynthesis.

Formative Practice 7.2

- 1 Aerobic respiration is the breakdown of glucose in the presence of oxygen to produce chemical energy.
- 2 Fructose, galactose.
- 3 Glucose + oxygen → carbon dioxide + water + energy
- 4 Sugar breakdown (glycolysis) takes place in the cytoplasm. Glucose (6-carbon) is broken down to two pyruvate molecules (3-carbon). In the next stage, pyruvate is oxidised through a series of reactions to produce carbon dioxide, water and energy. This stage takes place in the mitochondrion.

Formative Practice 7.3

- 1 Human muscle cells, some bacteria, yeasts and plants.

- 2 Organism: *Saccharomyces*
Product of fermentation: CO₂, ethanol
Example: wine, beer

Organism: *Aspergillus*
Product of fermentation: lactic acid
Example: soy sauce

Organism: *Acetobacter*
Product of fermentation: Acetic acid
Example: vinegar

- 3 When you sprint, the lungs and blood supply are unable to supply oxygen quickly enough to meet the demands of the muscles to produce ATP. In this condition, the muscle cells undergo fermentation, whereby ATP is produced without oxygen. Fermentation in muscle cells produces lactic acid.
- 4 • Aerobic respiration involves the complete breakdown of organic substances in the presence of oxygen whereas fermentation involves incomplete breakdown of organic substances in the presence of limited oxygen or absence of oxygen.
• Aerobic respiration takes place in cytoplasm and mitochondria but fermentation only takes place in the cytoplasm.
• Aerobic respiration produces water whereas fermentation does not.
• In aerobic respiration, glucose is oxidised completely into carbon dioxide and water whereas in fermentation, glucose is oxidised to ethanol or lactic acid.

Summative Practice 7

- 1 Ethanol is used in the production of beer and wine. Carbon dioxide is used in breadmaking to help the dough rise.
- 2 To provide the energy needed as well as enabling an individual to carry out activities.
- 3 This is because glucose oxidation is incomplete and a part of the chemical energy is still tied in the lactic acid molecule.

- 4 An athlete usually has more mitochondria in the muscle cells. Increased uptake of oxygen and oxidation of lactic acid reduces muscle fatigue.
- 5 100 m runners complete the race fast by holding their breath. By doing so, the runner uses existing oxygen efficiently. However, lactic acid is accumulated because the oxygen supply to the muscles is insufficient. On the other hand, long distance runners who run at a slower speed are able to dispose off the lactic acid accumulated in the early stages of running. Long distance runners cannot hold their breath because lactic acid accumulation causes rapid muscle fatigue. As such, long distance runners need to breathe throughout the race.
- 6 (a) (i) P: Aerobic respiration. Q: Fermentation
(ii) P: Carbon dioxide, water and energy
Q: Lactic acid and energy
- (b) When a person sprints, their muscle cells undergo fermentation in the absence of oxygen to produce ATPs. Muscles produce lactic acid that is toxic. Lactic acid causes cramps and muscle pain.
- (c) (i) Alcohol fermentation
(ii) Glucose $\rightarrow$ Ethanol + carbon dioxide + energy
(iii) Yeast

Essay Questions

- 7 (a) • To maintain body temperature at the optimum temperature of 37 °C.
• For division as well as growth and development of cells.
- (b) Similarities:
- Both are cellular respiration.
 - Both take place in animal and plant cells.
 - Both produce energy in the form of ATPs.
 - Both use glucose as the main substrate.

Differences:

Aerobic respiration	Fermentation
Uses oxygen	Does not use oxygen or uses limited oxygen
Complete glucose oxidation	Incomplete glucose oxidation
Respiration produces water, carbon dioxide and energy	Respiration in yeast: ethanol, carbon dioxide and energy Respiration in muscle cell: lactic acid and energy
Quantity of energy produced is big which is 2898 kJ	Quantity of energy produced is small Yeast: 210 kJ Muscle cell: 150 kJ
Process takes place in the cytoplasm and mitochondrion	Process takes place in cytoplasm.

- (c) The sugar in milk is oxidised by bacteria such as **Lactobacillus** and **Streptococcus** into lactic acid that solidifies the milk and produces a sour taste until curd is formed. When kept in the fridge, the low temperature controls bacterial activity from reproducing and spoiling the product. If kept at room temperature, the curd will spoil as bacteria will continue to grow and oxidise the milk sugar.

Enrichment

- 8 Someone who rarely exercises will experience muscle cramps when they do heavy exercises because the number of mitochondria in their cells are very few. Therefore, during vigorous exercise, complete cellular respiration does not take place and a lot of lactic acid will be formed. To overcome this problem, an athlete needs to undergo consistent training to produce more mitochondria in their cells. The high number of mitochondria can

help an athlete's cellular respiration. Faster uptake of oxygen and oxidation of lactic acid can reduce muscle fatigue during vigorous activities.

- 9** This is because baking powder has a high pH that is able to neutralise the lactic acid produced by muscles during exercise. This increases muscle efficiency because lactic acid causes muscle fatigue.
- 10** If the container still contains oxygen, the yeast will undergo aerobic respiration to produce carbon dioxide, water and energy. The rate of glucose breakdown is slow because the production of energy is high in oxygenated conditions. However, when the container no longer contains oxygen, the yeast will respire anaerobically to produce ethanol, carbon dioxide and energy. The energy produced

will be little, thus the yeast has to break down glucose faster to provide sufficient energy. The fast rate of glucose breakdown causes an increase in the rate of alcohol production. Subsequently, the rate of breakdown decreases as the high level of alcohol accumulation is toxic and can inhibit yeast growth. If the alcohol content reaches 14%, the yeast will die.

- 11** Susan should add a little lukewarm water into the dry yeast before mixing it into the flour. This step is to activate the dry yeast which is in a dormant state when its environment is dry. The activated yeast will undergo respiration by breaking down the carbohydrates in the flour and releasing carbon dioxide. Carbon dioxide causes the bread to expand and rise.

Model Answers

CHAPTER 8 RESPIRATORY SYSTEMS IN HUMANS AND ANIMALS

Formative Practice 8.1

- 1 • The large number of alveoli provides a large surface area for gaseous diffusion.
 - The inner lining of alveoli is always moist and enables respiratory gases dissolve in it
 - The alveoli are covered with a dense network of blood capillary that speeds up the diffusion of respiratory gases.
 - The alveolus wall is only one-cell thick, which eases gas diffusion
- 2 A frog's skin is very thin, constantly moist and densely supplied with a network of blood capillaries.
- 3 • The large number of tracheoles provides a large surface area for gaseous exchange.
 - Each body cell in an insect is supplied with a tracheole.
 - The walls of tracheoles are thin and constantly moist.
 - The ends of tracheoles have permeable walls and contain fluids that enable respiratory gases to dissolve and diffuse in and out of the respiratory surfaces.
- 4 Damaged gills reduce the total surface area available for an efficient gaseous exchange. Thus the fish may die due to a lack of oxygen.

Formative Practice 8.2

- 1 Spiracles are air pores that connect the respiratory structure of insects with the external environment.
- 2 • During inhalation, the abdominal muscles relax and the spiracle valves open. This reduces the internal pressure of the trachea causing air to be drawn into the trachea through the spiracle.

- During exhalation, the abdominal muscles contract. This increases the internal pressure of the trachea forcing air out through the spiracle.
- 3 • Fishes have filaments and gills as their respiratory structures while humans have alveoli.
 - The respiratory tract/opening of fish is the mouth and operculum while in humans, it is the nose.
 - 4 • The external intercostal muscles contract, the internal intercostal muscles relax.
 - The action causes the rib cage to move upwards and outwards.
 - At the same time, the diaphragm muscles contract and the diaphragm is lowered and flattened.
 - Both movements cause the volume of the thoracic cavity to increase and its pressure to decrease.
 - The higher atmospheric pressure outside forces air into the lungs.

Formative Practice 8.3

- 1 The partial pressure of oxygen is 160 mm Hg.
- 2 Carbon dioxide is transported in the form of bicarbonate ion, carbonic acid and carbaminohaemoglobin.
- 3 • When bicarbonate ions (HCO_3^-) in the blood plasma reach the lung capillaries, they diffuse again into the erythrocytes.
 - The bicarbonate ions combine with hydrogen ions (H^+) to form carbonic acid (H_2CO_3).
 - Carbonic acid (H_2CO_3) then dissociates into carbon dioxide and water.
 - Carbon dioxide diffuses out from the lung capillaries into the alveoli, and is expelled during exhalation.
- 4 Oxygen is transported in the form of oxyhaemoglobin.

Formative Practice 8.4

- 1 Bronchioles become inflamed, swollen and clogged.
- 2 The bronchiole walls swell and thicken. The opening of bronchiole tube becomes smaller and the airway becomes narrower.
- 3 Inhaler reduces inflammation and opens up the bronchiole tubes so that air can flow easily.
- 4 The alveoli walls become damaged. The surface area of the alveoli is reduced and gaseous exchange becomes less efficient.

Summative Practice 8

- 1 Each cell in an insect's body is supplied with a tracheole that directly enters the cell to enable gaseous exchange.
- 2 Amphibians do not have rib cage and diaphragm to help in the expansion and compression of the lungs.
- 3 Breathing becomes difficult because the volume and air pressure of the thoracic cavity cannot be increased nor decreased.
- 4 The increase in the rate of heartbeat causes oxygenated blood to flow to cells at a faster rate. This enables cellular respiration to occur at a faster rate to supply extra energy required during the state of panic. At the same time, carbon dioxide can be expelled at a faster rate.
- 5 (a)
 - The heat generated from cigarettes dries up the tracheal wall and damages cilia. The cilia produce more mucus.
 - Coughing is a reflex action to expel mucus. Cigarette smoke damages the alveoli, reducing the total surface area for gaseous exchange. This causes emphysema.(b) Lung cancer is caused by carcinogens that induce the growth of cancer cells.
(c) Tar that is deposited on the surface of alveoli, blackens them, reduces the efficiency of gaseous exchange and may cause cancer.
- 6 Less air is inhaled and exhaled, making breathing difficult. Air trapped in the alveoli may cause the alveoli to burst, producing a large air space in the alveoli. This means less total surface area for gaseous exchange.
- 7 (a) P: alveoli/lung, Q: gills
(b)
 - When the mouth opens, the floor of the mouth cavity is lowered. At the same time, the operculum cavity enlarges and the operculum closes. This reduces the pressure in the mouth cavity. Water containing dissolved oxygen from outside enters the mouth.
 - When the mouth closes, the floor of the mouth cavity is raised up. Water flows through the gill's lamellae and gaseous exchange occurs between the blood and water by diffusion. At the same time, the operculum muscles relax and the operculum cavity becomes smaller. The volume of the mouth cavity is reduced resulting in a higher pressure in the mouth cavity compared to the pressure outside. The high pressure forces water to flow out through the opening of the operculum.
 - The surface of P and Q is always moist because they are covered in a film of fluid that helps respiratory gases to dissolve. The large number of respiratory structures provides a large total surface area to volume ratio for respiratory gaseous exchange.
 - The rate of oxygen supply to all cells in the human body is high because humans have diaphragm and intercostal muscles to aid in the breathing mechanism. These are not found in fish. Besides, humans have a muscular heart that is able to pump oxygenated blood to the whole body faster.

Essay Questions

- 8 Similarities:
 - The respiratory surface is moist to dissolve oxygen for diffusion.

- The respiratory surface is thin for fast gas diffusion.
- The respiratory surface has a large ratio of total surface area to volume that allows more gases to diffuse through it.

Differences:

Humans	Insects
System/organ: lungs	System/organ: tracheal system
Air enters the trachea through the nostrils	Air enters the trachea through the spiracles
The nasal cavity does not have any valves	Spiracles have valves
The trachea branches into bronchus/bronchi	The trachea branches into tracheoles
Bronchus/bronchi end in alveoli	Tracheoles have dead-ends
Gaseous exchange occurs in the alveoli	Gaseous exchange occurs in the tracheoles
The trachea is supported by cartilage rings to prevent collapse	The trachea is supported by chitin rings
Alveoli is covered in a network of blood capillaries	The tracheoles are not covered with blood capillaries but come into direct contact with body cells
Oxygen is transported to body cells through blood	Oxygen diffuses directly from the tracheole to body cells
Gaseous exchange is facilitated by intercostal muscles and diaphragm	Gaseous exchange is facilitated by abdominal muscles

- 9 (a)
- Air is inhaled when the external intercostal muscles contract and the internal intercostal muscles relax.
 - This action causes the rib cage to rise upwards and outwards.
 - At the same time, the diaphragm muscles contract, lowering and flattening the diaphragm.
 - The volume of the thoracic cavity increases while the pressure decreases, and air is drawn into the lungs due to the higher atmospheric pressure on the outside.
- (b)
- The higher CO_2 partial pressure in body cells compared to that of the tissue capillaries causes CO_2 to diffuse from body cells into blood plasma.
 - A small portion of carbon dioxide blood plasma is dissolved and another portion is transported by the haemoglobin.
 - Most of the carbon dioxide diffuses into the red blood cells (erythrocytes).
 - In the erythrocytes, carbon dioxide combines with water to form carbonic acid (H_2CO_3).
 - Carbonic acid dissociates to bicarbonate ions (HCO_3^-) and hydrogen ions.
 - HCO_3^- diffuses into the blood plasma and is carried to the lungs. HCO_3^- ions then combine with H^+ to form carbonic acid (H_2CO_3).
 - Carbonic acid then dissociates to produce carbon dioxide and water.
 - The high in the lung capillaries as opposed to the low CO_2 partial pressure in the alveoli causes CO_2 to diffuse from the lung capillaries into the alveoli and subsequently, expelled through exhalation.

Enrichment

- 10 Frog is the most suitable animal as an indicator of air pollution level. Although the frog possesses a pair of lungs, the main respiratory organ is the skin. Unlike the heart, the air that diffuses through the skin is not filtered. Therefore, air pollution may cause the skin to be clogged by tiny particles. Clogged skin reduces the efficiency of gaseous exchange and cause death to the frog. Thus, frogs are more sensitive to air pollution compared to other vertebrates.
- 11 Whales are able to store a very high concentration of oxygen in their blood and muscles. They

inhale at the sea surface and hold their breath when submerging. Apart from keeping a high concentration of oxygen in their blood and muscles, body metabolism and heartbeat is reduced when whales dive. The arteries in some parts also constrict to reduce blood circulation to that particular part to save oxygen consumption. The saved oxygen is channelled to other important body parts such as the heart, sensory organs and brain. In this way, a whale is able to hold its breath for approximately 50 minutes before rising to the sea surface to breathe.

Model Answers

CHAPTER 9 NUTRITION AND THE HUMAN DIGESTIVE SYSTEM

Formative Practice 9.1

- 1 The food consumed by humans is in the form of large and complex molecules. The food needs to be broken down to a smaller and simpler form that can diffuse into the blood vessels and transported to body cells.
- 2 The structures that are involved in the digestion process are mouth, teeth, oesophagus, stomach, duodenum, small and large intestines.
- 3 The main cells in gastric glands are chief cells that secrete pepsinogen, parietal cells that secrete hydrochloric acid and goblet cells that secrete mucus.
- 4 The enzymes that are involved in the digestion process in the small intestine are trypsin, amylase, erepsin, sucrose, maltase, lactase and lipase.

Function of enzyme:

Trypsin—hydrolyses polypeptide to peptide

Amylase—hydrolyses starch to maltose

Erepsin—hydrolyses peptides to amino acids

Sucrase—hydrolyses sucrose to glucose and fructose

Maltase—hydrolyses maltose and glucose

Lactase—hydrolyses lactose to glucose and galactose

Lipase—hydrolyses lipids to fatty acids and glycerol

Formative Practice 9.2

- 1 The main structure in food absorption is villi.
- 2 (a) Blood capillaries
(b) Lacteal
- 3 Long small intestine. The inner layer of the small intestine is highly folded and covered with villi to

increase surface area for nutrient absorption. There are many microvilli found on the epithelial surface of the villi.

- 4 Glucose, galactose and amino acids are actively transported across the epithelial cell to the blood vessels by carrier proteins against the concentration gradient. Fatty acids and glycerols diffuse across the plasma membrane into the lacteal through simple diffusion.

Formative Practice 9.3

- 1 Assimilation refers to the use of absorbed nutrients to synthesise complex compounds.
- 2 The functions of liver in assimilation:
 - Carbohydrate metabolism
Glucose is oxidised to yield energy. Most of the excess glucose are converted to glycogen and stored in the liver.
 - Protein metabolism
Liver cells use amino acids to synthesise plasma proteins and enzymes.
 - Storage of nutrients
Besides storing glycogen, the liver provides a place to store vitamins and mineral salts.
 - Detoxification
The liver serves as a filter and detoxifies dangerous particles such as drugs, alcohol and other foreign substances.

Formative Practice 9.4

- 1 The main functions of the large intestine are water and vitamin reabsorption, and faeces formation.
- 2 Water, minerals, the metabolic by-products of bacteria such as vitamin B, K and folic acid.
- 3 The significance of water and vitamin absorption:
 - The absorption of water in the large intestine helps to form semi-solid faeces. This process enables the body to retain water.
 - The absorption of vitamins maintains health.

4 Formation of faeces:

- After the absorption of nutrients in the small intestine, the remaining mixture enters the colon.
- The remainder mixture consists of water, undigested food, bacteria, dead cells and cellulose.
- The movement of undigested food is facilitated by peristalsis.
- In the colon, the absorption of mineral salts and water takes place until faeces are formed.

Formative Practice 9.5

- 1 The intake of a high-fibre diet facilitates the movement of faeces and prevents health conditions such as constipation, colon cancer, rectal cancer and haemorrhoids. Some of the functions of fibres are to stimulate peristalsis, absorb and dispose off toxins, regulate glucose absorption especially in diabetic patients, and increase the bacterial population in the large intestine.
- 2 Gastric bypasses involves the reduction of the stomach's size using diverse operative methods. Among the short-term side effects are acid reflux, nausea and vomiting, dilated oesophagus, prohibition of certain types of foods, risk of infection and body weight gain or loss. Long-term side effects include nausea and dizziness, low blood sugar, malnutrition, stomach ulcer and complications in bowel movement.

Summative Practice 9

- 1 The intestinal juice of the individual may possibly not contain or lacks lactase to digest milk sugar (lactose) in the small intestine. As a result, the bacteria in the large intestine will digest the lactose to yield fatty acids and methane which causes diarrhoea and bloating. The individual is advised to drink lactose-free milk.
- 2
 - The gastric glands in the stomach secrete gastric juice.
 - Gastric juice contains hydrochloric acid and pepsin.

- The medium in the stomach is acidic and optimum for enzyme action.
- Protein is hydrolysed into polypeptides by pepsin.

- 3
 - The individual suffers from bulimia.
 - To retain his/her body mass, the patient induces purging.
 - The patient also experiences stress and anxiety.
 - The patient suffers from an imbalance of mineral ions in the blood.
 - This causes damage to the alimentary canal.

- 4 (a) X: Duodenum
Y: Pancreas
 - (b) (i) The bile and pancreatic juice are alkaline. These liquids help to neutralize the acids from the stomach.
 - (ii) Y secretes pancreatic juice that contains digestive enzymes into X. Pancreatic amylase hydrolyses starch to maltose.
 - (c) Pepsin hydrolyses protein to polypeptides.
 - (d) The acid in oranges reduces the pH value in the duodenum. This slows down starch digestion.

Essay Questions

- 5
 - Lipid digestion begins in the duodenum.
 - Bile salts produced by the liver emulsify fats into lipid droplets.
 - Pancreas secretes pancreatic juice which contains lipase into the duodenum.
 - Lipase hydrolyses lipid droplets to fatty acids and glycerol.
 - Lipid + water $\longrightarrow$ Glycerol + fatty acids
 - Absorption of fatty acids and glycerol occurs in the small intestine.
 - In the epithelial cells of villi, the condensation of fatty acid and glycerol forms lipid.
 - Lipid droplets are absorbed into the lacteals of villi.

- Lipid is transported from the lacteal by the lymphatic system into the thoracic duct and finally enters the blood flow through the left subclavian vein.
 - Assimilation occurs in the cells.
 - Cells use lipids to form the complex compounds of the plasma membrane.
- 6**
- Bread contains carbohydrate. The digestion of carbohydrate produces glucose.
 - Glucose is transported to body cells and the liver to be oxidised during cellular respiration to yield energy.
 - Excess glucose is converted into glycogen for storage.
 - The final product of butter is fatty acids and glycerol.
 - Lipid is oxidised to produce energy.
 - Some of the lipids are stored in adipose tissues.
 - The final product of proteins (egg and milk) is amino acids.
 - Amino acids are carried to body cells for enzyme synthesis and repair of damaged tissues.
 - Apple and milk provide vitamin and mineral salts.
 - Vitamins such as vitamin B are used as cofactors. Generally, vitamins and mineral salts maintain optimum health.
 - Apple also provides undigested fibre that facilitates defaecation.
- 7 (a)** A diet rich in fat is not good for health for the following reasons:
- A diet with a high content of fat and oily foods may cause high blood pressure and lead to cardiovascular diseases.
 - Excess fat will be deposited in the arterial walls (atherosclerosis) causing blocked arteries.
 - The lumen of the artery becomes narrow. This will make it difficult for blood to flow. The condition will increase blood pressure (hypertension).
- If the arterial lumen that becomes narrow is the coronary artery (artery in the heart), this may cause a heart attack due to the lack of oxygen supply to the cardiac muscles.
 - If the cholesterol hardens and clogs the coronary artery, heart attack or coronary thrombosis (lack of oxygen supply to the heart) may occur, resulting in damage to parts of the heart. This can turn fatal if pumping of the heart stops.
 - Excess cholesterol may also lead to gallstone formation.
- (b)**
- Foods with less carbohydrates and fats. Less carbohydrate will be converted to fats.
 - Foods with less fats and cholesterol. Less cholesterol will be deposited on the arterial walls blocking the arteries. Blood flow in the heart will also not be blocked.
 - The hydrolysis of starch by salivary amylase produces maltose. Next, the hydrolysis of maltose by maltase produces glucose. The final product of starch is glucose. Glucose is absorbed through the ileum epithelial cells and then absorbed into the blood circulatory system through blood capillaries.
 - Glucose is then transported by the hepatic portal vein to the liver.
 - Assimilation occurs in the liver. Depending on the body's needs, glucose in the liver is oxidised, excess glucose is converted into glycogen to be stored in the liver or changed to fats to be transported to other body parts for storage.
 - From the liver, some of the glucose is carried in the blood circulatory system to the heart and then pumped to the whole body.
 - In body cells, glucose is oxidised to yield energy, water and carbon dioxide.
 - Energy is used for chemical processes in the cell, for example, muscle contraction and protein synthesis. Excess glucose is stored in the muscles.

Enrichment

- 8 The drug/medicine may have been modified by the liver. The medicine that is absorbed through the small intestine is transported by blood to the liver. In the liver, any toxic components in the medicine is metabolised and converted into a less toxic form which is easily excreted through the kidney. Thus, the original molecular structure of the medicine swallowed is different from the one found in the blood.
- 9 Artificial sweeteners such as saccharine, aspartame and sucralose provide a sweet taste to the drinks, but contribute only a small caloric value. Sucralose is made from modified sucrose whereby three hydroxyl groups of the sucrose molecule are substituted by chlorine atoms. Sucralose stimulates taste buds (sweet) such as sucrose but it is not digested by enzymes. Therefore, sucralose does not give any caloric value to food. Sucralose is more stable compared to other artificial sweeteners.
- 10 The ingredients in fast or frozen foods usually contain a lot of fats, salt, sugar and processed chemicals.
 - Most of the fats found in fast or frozen foods are trans fats. Trans fats are fats that naturally exist in liquid form but have been modified to become solids. Trans fats make fast food last longer. However, trans fats can also increase the bad cholesterol (LDL) level and decrease the good cholesterol (HDL) level. This increases the risks of heart diseases and causes clogged arteries. Some fast foods contain red meat and cheese which naturally consists of saturated fats but can increase bad cholesterol.
 - Salt is usually used as flavour enhancer and as a preservative. A serving of fast food contains more salt than what our body needs on a daily basis. This may increase cholesterol level, and blood pressure. The high salt content in the food is also associated with kidney diseases.
 - Starch or complex sugar is used in fast food to enhance flavour and texture. The body will break down starch into sugars in the form of glucose during digestion. The excessive intake of sugar may cause serious health issues and is associated with increased risk of getting diabetes, heart diseases and obesity. Excessive sugar is also associated with depression.
 - Chemicals are added to fast and frozen foods to make it last longer and tastier. On the other hand, the high chemical content can be toxic to the body. For example, monosodium glutamate (MSG) is associated with headaches, nausea, chest pain, lethargy and breathing difficulties.
 - Sodium nitrates and artificial colourings that make fast foods appear fresh and attractive have been associated with various cancers. Some of the preservatives are actually carcinogenic (cause of cancer).
 - Besides, substances that are used as volume enhancers such as cellulose and potassium bromate may disturb the nutrient-absorbing system in the body. This contributes to various problems of the digestive system.

Model Answers

CHAPTER 10 TRANSPORT IN HUMANS AND ANIMALS

Formative Practice 10.1

- 1 Fishes have a single circulatory system whereas humans have a double circulatory system. Fishes have an atrium and a ventricle while humans have two atria and two ventricles.
- 2 Oxygenated blood mixes with deoxygenated blood because amphibians possess a single undivided ventricle.
- 3 The flat body of flatworms provide a large total surface area to volume ratio for the efficient diffusion of materials required by cells.
- 4 The open circulatory system in insects is unable to distribute oxygen to all body cells. Therefore, insects need a tracheal system to transport oxygen to support active activities.

Formative Practice 10.2

- 1 The bicuspid valve prevents the backflow of blood to the left atrium when the left ventricle contracts.
- 2 After donating blood, the reduction of blood especially in the brain may cause nausea and faint spells.
- 3 Erythrocyte is biconcave-disc shaped and does not have a nucleus, whereas leucocyte has no definite shape and possesses a nucleus.
- 4 The left ventricle needs to pump blood to the whole body through the aorta. The thick muscular wall produces a stronger contraction force.

Formative Practice 10.3

- 1 Sinoatrial node
- 2 Myogenic means the heart contracts and relaxes without receiving any impulse signal from the nervous system.

- 3 The blood flow back to the heart requires the contraction of skeletal muscles around the veins. If someone stands on his/her feet for too long, less oxygen flows to the brain, hence less oxygen and glucose are transported to the brain. This causes the individual to pass out.
- 4 When the blood flow is obstructed from flowing to the fingertips or when the blood vessels contract due to coldness.

Formative Practice 10.4

- 1 Fibrin is the strand of protein fibre that prevents blood loss when a person is wounded, and entry of microorganisms such as bacteria and foreign substances into the blood.
- 2 Haemophilia and thrombosis
- 3
 - Clumped platelets, damaged cells and clotting factor form thrombokinase
 - Thrombokinase (in the presence of Ca^{2+} and vitamin K) converts prothrombin into thrombin
 - Thrombin converts fibrinogen to fibrin
 - Fibrin forms a mesh of fibres across the wound and prevents loss of blood.
- 4 If blood clot is formed in the coronary artery, the cardiac muscles may die or suffer permanent damage due to the lack of oxygen supply. This may lead to a heart attack.

Formative Practice 10.5

- 1 Blood group O
- 2 The blood of the recipient will undergo agglutination.

3

Parents No. 1	Parents No. 2	Parents No. 3
Q	R	P

- 4 • In the final month of pregnancy, fragments of the first child's blood cells that has Rhesus antigen mixes with the mother's blood through the shedding placenta.
 - This induces the mother's immune system to produce antibodies against the Rhesus antigen.
 - The antibodies (anti-Rhesus) formed flow across the placenta into the fetal blood circulatory system.
 - Normally, the quantity of antibodies formed is not enough to affect the firstborn.
 - However, the antibodies that can destroy red blood cells remain in the mother's blood.
 - When a second child is conceived, which is also Rhesus positive, a small amount of fetal blood that enters the mother's blood will induce more anti-Rhesus secretion.
 - Antibodies that diffuse into the fetal blood circulatory system will destroy the fetal's red blood cells
 - The fetal's red blood cells experience haemolysis.

Formative Practice 10.6

- 1 Heart attack
- 2 Stroke occurs when a blood clot impedes blood flow to the brain.
- 3 A diet rich in lipids and low in fibre, lack of exercise, obesity and smoking.
- 4 • Plaque is formed and deposited on the arterial walls.
 - Plaque consists of cholesterol, lipids, fibrous connective tissues, dead muscle tissues and clumped platelets.
 - The plaque clogs and narrows the blood vessel's lumen.
 - Atherosclerosis is the early stage of arteriosclerosis.

Formative Practice 10.7

- 1 Right lymphatic duct and thoracic duct
- 2 The lymphatic system has three main functions:
 - The collection of excess tissue fluid to be returned to the bloodstream
 - The transport of lipids from the small intestine to the bloodstream
 - Body defence: Lymph nodes destroy pathogens and produce lymphocytes

3

Body fluids	Composition
Blood plasma	Plasma and cell components
Tissue fluid	Plasma without plasma proteins, erythrocytes and platelets
Lymph	• Plasma without plasma proteins, erythrocytes and platelets • More lipid droplets • Large number of lymphocytes produced by the lymph nodes

- 4 Fatty acids and glycerol (the digested fat-rich foods) diffuse into the lacteals in the villi of small intestines. These simple molecules then form a part of lymphatic components that are transported to the lymphatic vessel through the lacteal. Therefore, the number of lipid molecules in the lymph increases after a fat-rich meal intake.

Formative Practice 10.8

- 1 The parasitic infection that transmit the parasitic worm *Brugia* sp. can occur through mosquito bites.
- 2 If excess fluid is not returned to the bloodstream, body tissues become swollen due to excessive fluid accumulated in the interstitial spaces.

- 3 The patient may suffer from oedema due to the accumulation of tissue fluid in interstitial spaces. This is because the return of tissue fluid to the bloodstream requires the contraction of the skeletal muscles and the muscles on the lymphatic vessel wall.
- 4 Lipid globules are too large to diffuse into the blood capillaries but are able to diffuse through the small opening between the epithelial cells of lymphatic capillaries. This is because, unlike blood capillaries, the epithelial cells forming the walls of lymphatic capillaries are not continuous end to end. On the contrary, the ends of the lymphatic capillary cells overlap and can open like a one-way door to allow the diffusion of tissue fluid.

Summative Practice 10

- 1 Yes. Individuals with blood group O do not have antigen A or B on their red blood cells. They can donate blood to individuals with blood group B because no agglutination will occur.
- 2 • Low number of erythrocytes means that there are less haemoglobin to combine with oxygen to form oxyhaemoglobin.
 - This means that less oxygen is transported to body tissues for cellular respiration.
 - As a result, less energy is produced.
 - The individual becomes easily exhausted and looks pale.
 - He/She may have anaemia.
 - He/She must consume a lot of iron-rich foods such as spinach.
- 3 • The electronic pacemaker functions as a sinoatrial node that triggers the impulse to control and maintain heartbeat.
 - The generated electric impulse spreads to both atria and subsequently reaches the atrioventricular node
 - Next, the atrioventricular node transmits the rhythmic electric impulse throughout the ventricle and causing the heart to beat and pump blood.
- 4 • One example of nutrient is glucose.
 - The heart pumps blood from the artery to blood capillaries.
 - The arterial diameter is larger than the capillaries.
 - This produces a high hydrostatic pressure that forces glucose to diffuse from the blood capillaries into the interstitial spaces to form tissue fluid.
 - The glucose concentration in the fluid is higher than that of the cells.
 - Glucose diffuses into the cells via facilitated diffusion.
- 5 (a) Tissue fluid accumulates in the blocked vessels and cannot be returned to the blood circulatory system. The individual will suffer from oedema.
 - (b) Foot will swell
- 6 (a) • Deoxygenated blood pumped from the ventricle will enter the gill capillaries.
 - Gaseous exchange occurs in the gill capillaries.
 - From the gills, oxygenated blood flows back to all the body parts through systemic capillaries.
 - Deoxygenated blood transported in the veins will be circulated back to the heart's atrium.
- (b) The human circulatory system consists of a double circulatory system, whereas fishes have a single circulatory system. The human heart is made up of four chambers while fishes have only two chambers.
- (c) Both are closed circulatory systems because blood is contained in blood vessels when being circulated throughout the body.
- (d) The blood flow in fishes face more obstacles compared to humans because in fishes, the blood needs to be circulated through two capillary systems, that is, gill capillaries and

systemic capillaries before returning to the heart. The blood flow through capillaries poses resistance to the flow. Blood hydrostatic pressure against the capillary walls is reduced. This means that the oxygenated blood that leaves the gill capillaries flows at a slow rate. In humans, blood flows in large vessels, that is, arteries and veins before branching into arterioles and venules and ending with capillaries. The reduction of blood pressure occurs gradually and the flow of blood faces less resistance.

Fishes overcome this resistance by having sinus venosus, a large lumen replacing veins. The larger size of sinus compared to veins impose less resistance to blood flow.

Essay questions

7 Smoking

- Cigarette smoke contains nicotine.
- Nicotine causes addiction.
- Nicotine shrinks blood vessels.
- Nicotine increases blood pressure.
- Causes accumulation of plaque.
- Causes thrombosis/arteriosclerosis.
- Cigarette smoke contains carbon monoxide.
- Carbon monoxide competes with oxygen to combine with haemoglobin to form carboxyhaemoglobin.
- Affects oxygen transport efficiency
- Causes difficulty in breathing and heart attack
- Cigarette smoke contains tar that forms a film on the alveoli wall which reduces gaseous exchange

Imbalanced diet

- High intake of fats/lipid/carbohydrates
- Cholesterol and fats accumulate and are deposited in the lumen of blood vessels.
- The lumen of the coronary artery becomes small and narrow.
- This can cause atherosclerosis, stroke or thrombosis.

Unhealthy lifestyle

- Lack of physical exercise and a sedentary lifestyle
- Can cause obesity, stress, high blood pressure and heart attack

- 8 (a)
- The contraction of cardiac muscles is triggered and initiated by a group of specialised tissues known as sinoatrial node.
 - Sinoatrial node generates electrical impulses similar to the ones generated by nerves.
 - As the cardiac muscles are continuous and criss-cross each other, when a cell is stimulated, the stimulus is spread or conducted throughout the atrial wall of the heart.
 - The waves of contraction are transmitted throughout the atria causing the atria to contract simultaneously and uniformly.
 - The electrical impulse will spread to a second group of nodes known as the atrioventricular node.
 - The electrical impulse will then spread through the bundle of His and Purkinje fibres till it reaches the apex of the heart.
 - This induces a rhythmic electrical impulse wave throughout the ventricles and both ventricles contract simultaneously starting from the bottom to the base of the aorta and pulmonary artery.
- (b)
- Ali needs to walk or move his feet so that the skeletal muscles on his feet can contract.
 - The contraction of the foot skeletal muscles produce a force that pushes blood in the veins to return to the heart.
 - The contraction of muscles also force blood to flow to foot tissues that suffer from a shortage of blood supply.

- (c) Beef *rendang* and *nasi lemak* cooked with coconut milk contain high lipid (triglycerides) and cholesterol.

Normally, the human body tends to store fats instead of using it to supply energy.

As a consequence, excess fats and cholesterol will be deposited on arterial walls (arteriosclerosis)

- The arterial lumen will become narrow, obstructing blood flow.
- This condition increases blood pressure (hypertension).
- The heart needs to work harder to pump blood. This adds more pressure to the heart.
- If the arterial lumen that becomes narrow is the coronary artery (the artery in the heart), a heart attack may occur, especially during an activity, or a person's emotional condition which causes the heart to work harder. This condition is called angina and is caused by the lack of oxygen supply to cardiac muscles.
- The lack of blood and oxygen supply to the heart can cause some parts of the cardiac muscle to die. It can also turn fatal.
- If the deposits of cholesterol and fats, together with blood clots move to other parts, for example the brain, stroke may occur.

- Therefore, the individual should quit unhealthy eating habits in order to prevent stroke, hypertension and cardiovascular diseases.

Enrichment

- 9 (a) • Blood is able to flow back to the left ventricle when the left ventricle contracts to pump blood out through the aorta.
- Body tissues will receive less oxygenated blood.
 - Blood circulation becomes slower and pressure drops.
- (b) The incomplete septum development causes deoxygenated blood to mix with oxygenated blood. Hence, the baby will experience shortage of oxygen.
- 10 The treatment that can be done is coronary artery bypass surgery and placing a stent in the blood vessel.
- 11 The bandage needs to contain a lot of thrombin and fibrinogen to stop blood flow. The bandage can be used during an emergency to cover accident wound(s).

Model Answers

CHAPTER 11 IMMUNITY IN HUMANS

Formative Practice 11.1

- 1 Immunity is the body's ability to fight against disease infections caused by pathogens or foreign substances, by specifically fighting the particular pathogen.
- 2 The skin is a physical defence that prevents the entry of pathogens. The pH of the skin which ranges from 3 to 5 provides an acidic environment which is unfit for microbial growth.
- 3 Phagocytes carry out phagocytosis by surrounding, trapping and digesting pathogens.
- 4 Antigen is a foreign substance that enters the body. Antigen is usually a protein molecule found on the wall or external membrane of a pathogen. Antibody is a protein produced by lymphocytes that functions to destroy the antigen.

Formative Practice 11.2

- 1 Artificial passive immunity. The body does not produce its own antibody; therefore, the immunity does not last long and only provides a temporary protection.
- 2 An antiserum injection against snake venom provides immediate protection but only for a short term. The immunity is acquired immediately after the injection.
- 3 The period of immunity for artificial passive immunity is shorter than that of artificial active immunity.
- 4 Immunisation helps to boost the immune system by stimulating the body's defence cells which then protect us from any possibility of life-threatening complications. Therefore, we are advised to comply with and complete the immunisation plan as early as possible according to the recommended schedule.

Formative Practice 11.3

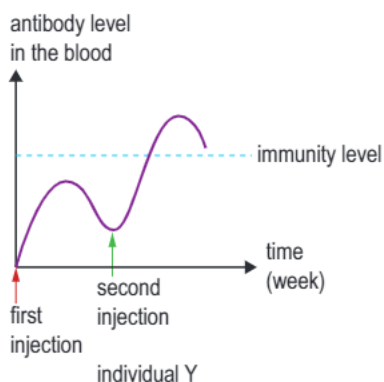
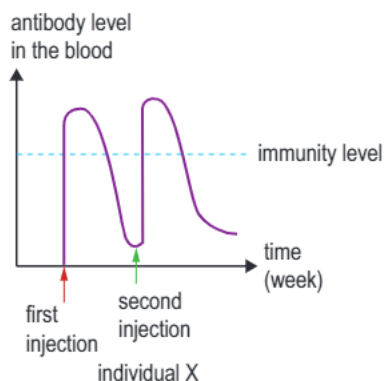
- 1 AIDS is Acquired Immunodeficiency Syndrome.
- 2 The HIV virus attacks and disables the immune system of the individual infected by the virus. The HIV virus attacks and destroys lymphocytes that function to destroy pathogenic microorganisms. This may result in the individual contracting AIDS or acquired immunodeficiency syndrome. The immune system of the patient becomes so weak that his/her body is unable to fight against diseases that would normally not infect individuals with healthy immune systems.
- 3 A person who is infected with HIV can be a carrier without showing any symptoms for a period longer than 10 years. This individual will only develop AIDS if his/her immune system becomes weak and less resistant to diseases that are usually not harmful. An example of a disease that can prove fatal to an AIDS patient is pneumonia. Thus, someone who is infected by the HIV virus does not necessarily contract AIDS, as long as his/her immune system stays strong and is not crippled by the HIV virus.
- 4 AIDS can be prevented by avoiding risky activities such as unprotected sex with infected individuals, sharing contaminated needles used for drug abuse or tattooing, or receiving transfusion of HIV-infected blood.

Summative Practice 11

- 1 The individual must be given a serum injection containing antibodies that can fight the toxin found in the snake venom.
- 2 Through the mother's placenta to the foetus in the womb, or breastfeeding
- 3 (a) Natural passive immunity
(b) Through the placenta, antibodies are able to diffuse from the mother to the foetus. When antibodies enter the foetus, they will act on the pathogen. This provides immunity to the foetus and prevents disease infection.

- 4 (a) (i) X: Artificial passive immunity
Y: Artificial active immunity
- (ii) X: Antiserum
Y: Vaccine
- (iii) Antiserum is blood plasma that contains antibodies or antitoxins for a particular disease. Vaccine is dead or weakened antigens which are injected into a person's body to induce his/her immune system to produce the required immunity.

(b) (i)



- (ii) • Individual X: The second injection is required to increase the quantity of antibodies beyond the immunity level because the quantity of the antibodies drops below the immunity level after a period of time.

- Individual Y: The second injection is needed to induce more antibodies beyond the immunity level because the first dose is insufficient for the individual to achieve the required immunity level.
- (iii) • The immunity acquired by individual X is immediate while the immunity acquired by individual Y is slow.
- The period of immunity for individual X after reaching immunity level is temporary but for individual Y, it is permanent.

Essay questions

- 5 (a) In individual X, lymphocytes are stimulated to produce antibodies that destroy antigens. Memory cells remain in the body. Individual X acquires natural active immunity and is able to fight against the disease in the future.
- (b) The suspension that is injected into individual Y is a vaccine. Vaccine is weakened pathogens used to induce lymphocytes to produce antibodies. Individual Y acquires artificial active immunity and obtains immunity against measles.
- 6 (a) • A newborn needs to acquire immunisation based on the Immunisation Plan because, the baby does not acquire immunity against certain diseases from the mother (natural passive immunity) during the foetal stage.
- Also, after the baby reaches the age of 6 months, his/her natural passive immunity will recede.
 - Furthermore, the baby maybe exposed to various infectious diseases, for example measles. Babies are unable to fight infections because they do not have the immunity against the disease.
 - Therefore, babies must be given immunisation for him/her to acquire immunity against diseases.

- (b) (i) One dose is sufficient to induce the body's immune system to produce an antibody concentration that exceeds the immunity level and permanent throughout life to prevent infections.
- (ii) Sinti may contract hepatitis B if she is exposed to the hepatitis B virus because the antibody level in her body has not reached the required concentration to offer complete protection from the disease.
- (iii) • For an immediate treatment, Aziman needs to be given an antitetanus injection. Antitetanus contains antibodies that will act against tetanus. The rusty nail stepped on by Aziman may contain *Clostridium tetani* that can cause tetanus (lockjaw).
- As the antibodies for tetanus is already available in the antitetanus, the antibodies can act immediately against the bacteria.
 - The body immune system does not need to be stimulated to produce antibodies against the disease.
 - Thus the immunity acquired by Aziman is known as artificial passive immunity.
 - The antiserum injection can save Aziman immediately compared to immunisation that will take a long time to stimulate the body's immune system to produce the required quantity of antibodies.
- (c) • The HIV virus attacks and cripples the immune system (lymphocytes), rendering the body incapable of fighting diseases.
- Bacteria, yeasts, parasites and viruses that normally do not cause any serious diseases in individuals with healthy immune systems can now endanger and become fatal to those with AIDS.

- This is because the HIV virus attacks and destroys cells that carry the CD4 molecule on their surface, for example, T lymphocyte. The function of the T lymphocyte is to destroy pathogenic microorganisms. In an infection, the T lymphocyte becomes a host for the HIV virus. The HIV virus will attach itself to the plasma membrane of the T lymphocyte and start building its DNA's genetic materials.
- The viral DNA then enters the nucleus of the T lymphocyte, combines with and becomes a part of the T lymphocyte's DNA.
- In the T lymphocyte, the HIV virus can replicate to produce new HIV populations that will attack other T lymphocytes. In this way, the HIV virus will cripple the immune system of the infected individual.

Enrichment

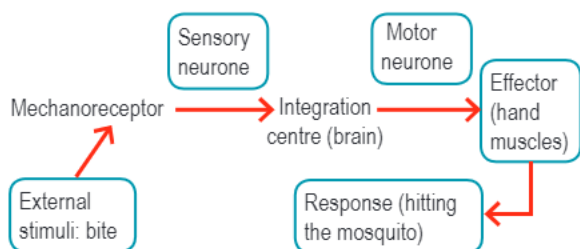
- 7 If the antibiotic prescribed is not taken completely, the undestroyed bacteria will become immune towards the antibiotic. This will produce a bacterial strain which is immune to the antibiotic. This strain of bacteria will grow rapidly and the existing antibiotic would not be able to destroy it anymore. Thus once infected, treatment with the available antibiotic will not be effective and the immune system may not be able to fight against the new bacteria strain.
- 8 • Wash your hands using antiseptics after visiting.
- Cover your mouth with a mask when talking to patients.
 - Avoid touching any hospital equipment.

Model Answers

CHAPTER 12 COORDINATION AND RESPONSE IN HUMANS

Formative Practice 12.1

- 1 Response refers to how an organism reacts after detecting a stimulus.
- 2 Skin
- 3 Coordination is very important to humans because any changes that occur in the external environment or in the body can be detected and an appropriate response can be executed.
- 4



Formative Practice 12.2

- 1 The brain receives various types of information from the receptor. It analyses, integrates and links the information together to form a meaningful overview. After the information is processed, appropriate response(s) will be determined and effectors are directed to execute the response(s).
- 2 The cerebellum functions to control and regulate body movement as well as maintain body balance. The medulla oblongata controls involuntary responses such as peristaltic action.
- 3 The somatic nervous system controls all voluntary actions while the autonomic nervous system controls involuntary actions.
- 4 We cannot refrain from sneezing because it is an involuntary action.

Formative Practice 12.3

- 1 The motor neurone receives nerve impulses from the relay neurone of the central nervous system and transmits them to an effector such as muscles or glands for an appropriate response.
- 2 To generate the required energy needed for the transmission of nerve impulses.
- 3 Electrical impulses are transmitted through the synapse chemically, by means of neurotransmitters.
- 4 The transmission of nerve impulses is slowed down because there are no Ranvier nodes.

Formative Practice 12.4

- 1 Receptor → Sensory neurone → Relay neurone in the spinal cord
Effector ← Motor neurone ←
- 2 Reflex action is defined as a quick and automatic response that does not involve thinking. Reflex action is important to protect ourselves from threatening situations and guarantees survival in the ever-changing environment
- 3 Voluntary action is an action under conscious control while involuntary action is an action we have no control over.
- 4 The condition may be due to the presence of sensory neurones at the amputated part. Therefore, the neurotransmitters secreted by the sensory neurones at the amputated part trigger nerve impulses and are interpreted by the brain as pain.

Formative Practice 12.5

- 1 The patient forgets easily and loses his/her sense of direction even in familiar places. If the brain degeneration continues, he/she will lose the ability to read, write, eat, walk and speak.
- 2 Drugs speed up or slow down impulse transmission at the synapse by obstructing the action of substances that transmit synapse.

- 3 To reduce nausea and pain of the patient
- 4 Alcohol impairs the brain's ability to estimate distance while driving, and to coordinate.

Formative Practice 12.6

1

Hormone	Function
Oxytocin	Stimulates contraction of the uterus' smooth muscles during childbirth
ADH	Stimulates water absorption by the kidney
Thyroxine	Increases the metabolism rate of most body cells

- 2
 - Secreted by a specialised gland known as the endocrine gland
 - Required in a small quantity only
 - Effect/influence period is long
- 3
 - The nervous system transmits information rapidly through nerve impulses; the endocrine system transmits information at a slower pace through hormones.
 - An impulse induces response from one organ only but a hormone induces response from several organs.
 - The effect of a hormone is usually long-term and permanent until it is removed from the blood.
 - A nerve impulse produces a quick and short response.
- 4 In a threatening or 'fight or flight' situation, the hypothalamus transmits nerve impulses directly to the adrenal medulla to secrete adrenaline and noradrenaline. Both hormones quickly act by producing the required response in a 'fight or flight' situation. These include increased heartbeat rate, respiratory rate, blood pressure, blood glucose level, and metabolic activities. In a 'fight or flight' situation, the heart needs to pump more

oxygen and glucose to the brain and skeletal muscles. This is because the brain must be very alert and prepared to move the body, and the skeletal muscles need energy to fight or to run away quickly. This means that in a threatening situation, both the endocrine and nervous systems cooperate to produce an immediate response to face the threatening situation. After the mechanism succeeds in controlling the threatening or 'fight or flight' situation, the body condition returns to normal.

Formative Practice 12.7

- 1 The posterior lobe of the individual's pituitary gland failed to secrete antidiuretic hormone (ADH).
- 2 Blurred vision and wounds take longer time to heal
- 3 Goitre happens due to the failure of thyroid gland to produce sufficient thyroxine. This may result from a lack of iodine since thyroxine contains iodine. Seafood contains high iodine content. Therefore eating a lot of seafood may be able to increase the body's iodine content
- 4 The gene for human growth hormone was successfully inserted into *Escherichia coli*. This enables the mass production, isolation and purification of the hormone for commercial use. Stunted children can be injected with this growth hormone.

Summative Practice 12

- 1 The cerebellum controls and coordinates body movement as well maintains body balance. The medulla oblongata controls involuntary responses such as peristalsis.
- 2 Reflex action is defined as a rapid and automatic response without thinking. The ability to carry out reflex action is important because it protects us from harmful situations and guarantees our survival in the ever-changing environment.
- 3 The main endocrine gland is the pituitary gland because it secretes a number of hormones

that induce other endocrine glands to secrete hormones.

4 Effect of deficiency — dwarfism

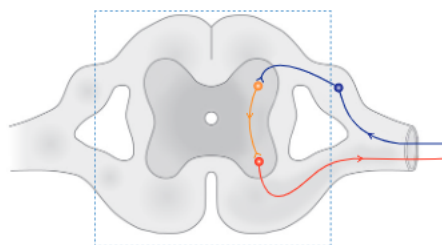
Effect of excess — gigantism

5 (a) (i) Spinal cord

(ii) X contains neurones to transmit impulses to and from the brain.

(b) The cell bodies of sensory neurones are clustered in Y (dorsal root ganglion).

(c)



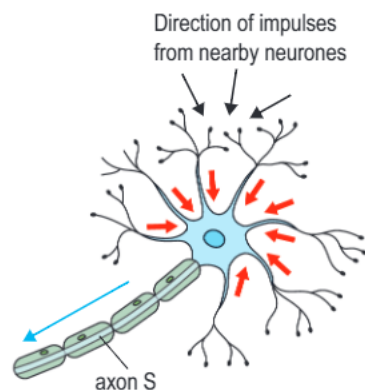
(d) If the spinal nerve in Z is cut, the motor neurone will not be able to convey information to the effector (such as muscles and glands), and the effector will not be able to respond to the commands of the spinal cord.

6 (a) V – mitochondrion U – vesicle T – synapse

(b) Neurotransmitter

(c) Generate energy for electrical impulse transmission

(d)



(e) (i) To continue the transmission of the electrical impulse to the next neurone upon reaching the synaptic knob

(ii) Synaptic vesicles secrete neurotransmitters that diffuse across the synapse and attach to the receptor proteins on the receiving neurone dendrite. The dendrite is then stimulated to trigger a nerve impulse that is carried by the receiving neurone to the effector.

(f) Impulse transmission occurs in one direction only because after being secreted from the synaptic vesicles, neurotransmitters will move across the synapse, and fuse with the receptor of the next neurone. Therefore, impulse transmission takes place in one direction only.

Essay Questions

- 7** • Stimulants such as cocaine prevent the removal of the neurotransmitters that stimulate excitement.
- This will produce an intense euphoric feeling followed by depression.
 - Stimulants also increase impulse transmissions that cause increases in the heartbeat and respiration rates.
 - Depressants such as heroine will retard and slow down the activities of the nervous system.
 - This slows down the production of neurotransmitters which will then reduce the rate of heartbeat and respiration.
 - The individual will experience temporary excitement and satisfaction.

- 8** (a) (i) The nervous system and endocrine system have a number of similarities:
- Both have specific target organs.
 - Both respond to certain stimuli.
 - Both function to coordinate all body activities.

The nervous system and endocrine system also have some differences:

Nervous system	Endocrine system
Consists of a network of millions of neurone cells	Consists of endocrine glands without ducts
Messages are conveyed in the form of electrical impulses through neurones	Messages are conveyed by organic chemical substances known as hormones through the bloodstream
Effect is rapid and immediate.	Effect is slow
Effect involves response of one organ	Effect involves responses of a few organs
Short-term effect. The effect ceases as the impulse comes to an end.	Long-term effect.

- (ii) • A sharp nail that pierces through the skin causes the sensory receptor in the skin to generate nerve impulses.
- The nerve impulses are transmitted along the sensory neurone to the spinal cord.
 - In the spinal cord, the nerve impulses are conveyed from the sensory neurone to the relay neurone.
 - From the relay neurone, the nerve impulses are transmitted to the motor neurone.
 - The motor neurone carries the nerve impulse from the spinal cord to the effector (muscle tissues) so the foot can be moved immediately.

- (b) • Azman is aware of his action when riding a bicycle because his action involves a voluntary response under his conscious control.
- He is not aware of the food digestion in the digestive tract because digestion is an involuntary response which is beyond his conscious control.
 - The control centre involved in riding the bicycle is the central nervous system and involves the musculoskeletal system.
 - Azman has past experiences on how to ride a bicycle. This information is triggered in the motor area of the cerebral cortex.
 - Since the information is triggered in the cerebral cortex, it is a conscious response.
 - The information is then transmitted to the effectors, that is, the skeletal muscles on the foot and arm through the motor neurone.
 - The contraction of the skeletal muscles enables Azman to ride the bicycle at his own will. Besides cerebral cortex, information on the body balance is also sent from the balance receptor in the ears to the control centre.
 - The control centre involved in food digestion is the medulla oblongata and the muscles involved are the smooth muscles.
 - The presence of food in the digestive tract triggers impulses on the receptor and information is sent to the medulla oblongata.
 - This information is conveyed to the smooth muscles through the motor neurone. The smooth muscles contract and relax in rhythm to produce a wave of peristalsis that will move the food along the digestive tract.
 - Since the information does not reach the cerebral cortex which is responsible for voluntary responses, the perception of food peristalsis does not arise.

Enrichment

- 9 The brain makes decisions based on past experiences. It knows that a book is heavier than a piece of paper. Therefore, the brain stimulates a number of muscle fibres depending on the energy required. Some motor neurones are able to stimulate many muscle fibres whereas some can only stimulate a few muscle fibres. The motor neurones that are able to stimulate a large number of muscle fibres will produce more lifting force compared to the ones that stimulate a few muscle fibres. Therefore, in order to lift a book, the brain

will stimulate the motor neurones that stimulate many muscle fibres.

- 10 A patient with Alzheimer's or Parkinson's suffers from brain neurone degeneration that affects mental functions. Due to the loss of various mental functions that include memory, movement and emotional changes, the patient often requires full-time intensive care. Therefore, the caregiver should have a good understanding of the medical condition and display perseverance in taking care of these patients.

Model Answers

CHAPTER 13 HOMEOSTASIS AND THE HUMAN URINARY SYSTEM

Formative Practice 13.1

- 1 Homeostasis is the regulation of the physical and chemical factors of the internal environment within a normal range so that cells can function optimally.

The mechanism of homeostasis occurs by negative feedback:

- A value that exceeds the normal range is reduced back to normal.
 - A value that drops below the normal range is raised back to normal.
- 2 Mechanism of homeostasis:
 - Vasodilation occurs
 - Sweat glands secrete sweat
 - Erector muscles relax – body hairs are lowered
 - Skeletal muscles contract and relax lesser. Body does not shiver.
 - The adrenal and thyroid glands are less stimulated – metabolism rate is lowered
 - 3 Excess glucose is not converted into glycogen. The glucose level in the blood rises (hyperglycaemia) and glucose is excreted through the urine (glycosuria). In this condition, the individual is considered as having diabetes mellitus. A diabetic patient is constantly feeling thirsty, exhausted and lethargic and experiences weight loss. If left untreated, it may lead to death.
 - 4
 - Blood pressure rises. The baroreceptor on the aortic arch and arterial carotid are stimulated.
 - The cardiovascular control centre in the medulla oblongata is stimulated.
 - The smooth muscles of the artery wall relax (vasodilation), hence reducing resistance to blood flow in the blood vessels.
 - The cardiac muscles contract weakly.
 - Blood pressure returns to normal.

Formative Practice 13.2

- 1 The proximal convoluted tubules and distal convoluted tubules are found in the cortex, whereas the loop of Henle is found in the medulla.
- 2 Eating salty foods and drinking less water
- 3 Water is reabsorbed through osmosis. The reabsorption of sodium ions and glucose occurs through active transport.
- 4 The individual does not need to undergo haemodialysis. The individual only needs to reduce food rich in protein and salt as well drink enough water.

Formative Practice 13.3

- 1 Kidney stones may block the ureter and reduce the production of urine.
- 2 Not drinking enough water and excessive intake of mineral salts such as calcium

Summative Practice 13

- 1 The loop of Henle can be found in the kidney medulla.
- 2 (a) Diluted urine in large amounts
(b) Concentrated urine in small amounts
- 3 Benedict's tests
- 4 The liver slows down cellular respiration, converts glycogen to glucose and prevents the conversion of glucose to glycogen.
- 5 (a) The amino acid concentration in blood plasma is higher than that found in the urine. Reabsorption occurs. 100% of the amino acids are reabsorbed into the blood capillaries through active transport at the proximal convoluted tubule.
(b) The kidney failed to function as osmoregulatory organ. The water content in the body cannot be regulated.

- 6 (a) • Absence of lipase. This means less fat digestion.
- Absence of trypsin. This means less protein digestion.
 - When insulin and glucagon are not produced, the regulation of blood sugar level is affected.
- (b) • Reduce the intake of carbohydrates
- Get an insulin injection if the blood glucose level rises above normal.

- 7 (a) Ultrafiltration
- (b) Blood cells and plasma protein
- (c) The diameter of the afferent arteriole that carries blood into the glomerulus is larger than the diameter of the efferent arteriole that carries blood out of it. This creates a high hydrostatic pressure in the glomerulus, and pushes molecules of specific sizes such as glucose and amino acid out across a two-cell thick wall between the capillary wall and the inner wall of the Bowman capsule.
- (d) Glucose was reabsorbed in the proximal convoluted tubule through active transport.
- (e) Animals that live in a dry environment have a longer loop of Henle compared to animals living in a moist environment. This enables more water to be absorbed through the loop of Henle. The result is concentrated urine.

Essay Questions

- 8 • The body temperature of the worker drops after sitting in a cold room for 6 hours.
- The thermoreceptors on the skin receive stimuli and transmit nerve impulses to the temperature control centre in the hypothalamus through afferent nerves.
 - A negative feedback mechanism occurs:
 - Vasoconstriction takes place. This reduces the flow of blood to the skin surface and hence less heat flows to the surrounding.

- Sweat glands are not stimulated. Therefore, no sweating occurs.
- Erector muscles contract, causing body hairs to rise. A thick layer of air is trapped on the skin surface and acts as a heat insulator that prevents the loss of heat through the skin.
- Body shivers. The skeletal muscles contract and relax, generating heat and increasing body temperature.
- The thyroid gland is stimulated to secrete thyroxine and the adrenal gland is stimulated to secrete adrenaline. Thyroxine increases cell metabolism rate and adrenaline increases glycogen conversion into glucose. Glucose is oxidised to yield heat energy.

- 9 • There is less oxygen in the atmosphere.
- The oxygen partial pressure is low.
 - There is less oxygen in the blood.
 - This is detected by the peripheral chemoreceptors. Nerve impulses are generated and sent to the respiratory and cardiovascular control centres, and then to the intercostal muscles, diaphragm and cardiac muscles. The rate of contraction and relaxation of the intercostal muscles and diaphragm increases, hence increasing the breathing (inhale/exhale) rate. Heartbeat also increases.
 - More oxygen is brought to the cells and more carbon dioxide is transported to the lungs.

- 10 • The erector muscles relax, causing the body hairs to lean towards the skin surface.
- Body hairs trap a thin layer of air allowing more heat to be released to the surrounding.
 - Sweat glands secrete sweat. When the sweat evaporates, heat is lost to the surrounding.

- 11 (a) (i) The optimum temperature for all enzyme-catalysed chemical reactions is 37 °C. If the body temperature rises, enzyme-controlled metabolic reactions will be affected because the enzymes will become denatured.

- (ii) • The erector muscles of the skin contract, raising body hairs. A layer of air trapped on the skin surface, functions as an insulator.
- When stimulated, skeletal muscles contract and relax more. The body shivers and heat is generated.
- (b) • Protein is digested into amino acids.
 - Excess amino acids are toxic and cannot be stored.
 - Through deamination, the nitrogenous part of amino acids is converted to urea while the non-nitrogenous (carbon chain) part is converted to glycogen or fat for storage.
 - Urea is a nitrogenous waste product that needs to be excreted through the urine.
 - Since the urea concentration is high in a person who ate too much protein-rich foods, urea needs a lot of water to be excreted.
 - Therefore, he/she will pass urine frequently.
- (c) • When a person drinks too little water, the blood osmotic pressure will increase above normal levels.
 - The osmoreceptor in the hypothalamus is stimulated. Nerve impulses are transmitted to the pituitary gland to secrete more antidiuretic hormone (ADH) into the blood.
 - A high concentration of ADH increases the permeability of the distal convoluted tubule and collecting duct walls.
 - More water is reabsorbed from the filtrate into the blood.
 - Urine becomes more concentrated and only a small amount is excreted.

- As a consequence, blood osmotic pressure drops and returns to the normal range.
- Low osmotic pressure creates a negative feedback mechanism that reduces the activities of the osmoreceptor cells in the hypothalamus.
- This will then cause the pituitary gland to cease secreting more ADH.

Enrichment

- 12** Seawater fishes do not experience dehydration although sea water is hypertonic to the body fluids due to homeostasis. Through homeostasis, most water is reabsorbed into the blood. Only a small amount of concentrated urine is excreted. Fishes also drink a lot of sea water to replace water loss. Excess salt is expelled through specialised cells found on the gills, that is, chloride cells. All of these maintain the osmotic blood pressure of the fish so that dehydration does not occur.
- 13** Drugs in the bloodstream are secreted into the renal tubule and excreted through urine. By testing the presence of drugs in urine, we can determine whether a person is taking drugs or not.
- 14** In applying the silicone nanotechnology to produce a semipermeable membrane filter that lasts long, the following should be taken into account:
 - The apparatus does not require installation of a tube.
 - The apparatus must be small and can be inserted into the body without triggering any rejection from the immune system
 - Able to carry out ultrafiltration process, remove all toxins and reabsorb all substances needed by the body.

Model Answers

CHAPTER 14 SUPPORT AND MOVEMENT IN HUMANS AND ANIMALS

Formative Practice 14.1

- 1 Body shape is important for movement and support, and enables organs in the body to function properly.
- 2
 - To protect the internal organs in vertebrates (for example, the skull protects the human brain)
 - To produce red blood cells (in the bone marrow)
- 3 Animals with legs below the body (for example, mice) lift their body mass above the ground to reduce friction while moving.

Formative Practice 14.2

- 1 The skull, vertebral column, rib cage and sternum.
- 2 The cartilage acts as cushion to joints, absorbs shock and reduces friction between the ends of bones. Synovial fluid acts as a lubricant that reduces friction between the ends of bones.
- 3
 - Tendon is not elastic but ligament is.
 - Tendon connects muscle to bone. Ligament connects bone to bone.
- 4 Ball-and-socket joints allow rotational movement in all directions whereas hinge joints only allow the movement of bones in one plane.

Formative Practice 14.3

- 1 Hollow bones are light which facilitates flying.
- 2 When biceps contracts, the tendon transmits a pulling force produced by the contracting muscles to the arm. At the same time, triceps relaxes. As a result, the elbow bends and the arm moves up.
- 3 The vertebral column of fish is flexible and moves from side to side through the contraction and relaxation of myotome, W-shaped muscle segments. When the right myotome contracts, the left relaxes and the tail is whipped to the right. On

the other hand, when the left myotome contracts, the right relaxes and the tail is whipped to the left. Waves of alternate contractions and relaxations along the myotome causes the body parts to move from side to side, pushing water backwards and sideways, thus moving the body forward.

- 4 Grasshoppers have long hind legs that can be folded into a Z-shape, and in this position, it functions as a jumping spring. When the hind legs are in the Z-position, the extensor and flexor muscles are undergoing contraction. When the extensor muscles of the hind legs contract and straighten rapidly backwards and downwards to the ground, it provides the grasshopper a lifting force that pushes it up and forward into the air.

Formative Practice 14.4

- 1 Practice a balanced diet intake and correct body posture.
- 2
 - In the case of a minor scoliosis, doctors will carry out routine observation until the maturity level of the bone is almost completed.
 - Special equipment to support the backbone (bracing)
 - Surgery
- 3 Osteoporosis is a disease whereby the bones become thin, porous and break easily. Osteoporosis can be prevented by taking calcium, phosphorus and vitamin D.
- 4 To maintain a healthy musculoskeletal system, we must wear proper attire, exercise and practise correct body postures.

Summative Practice 14

- 1 The cervical vertebra possesses a short spinous process, a small centrum, wide transverse processes and a pair of transverse foramina. The thoracic vertebra has a long spinous process, short but bigger and thicker centrum. The transverse processes are longer but no transverse foramen is present.

- 2 Segment T: Circular muscles contract
Segment S: Longitudinal muscles contract
- 3 Body shape is important for movement and support, and enables body organs to function properly.
- 4 • Good posture refers to the correct way of sitting, standing, kneeling and carrying out other body movements.
- We need to practise good posture because good posture provides perfect support to the musculoskeletal system, eases blood flow, reduces injury to skeletal muscles and relieves pressure to the vertebral muscles and column.
- 5 • Muscle contraction needs a lot of ATP energy produced during cellular respiration.
- A large amount of blood is needed to transport and supply oxygen and glucose to the muscle cells.
 - At the same time, blood transports waste products such as carbon dioxide and lactic acid out of the muscle cells.
- 6 (a) X: Lumbar vertebra
Y: Cervical vertebra
- (b) The vertebrae provide a surface for muscle attachment. The vertebral column consists of many vertebrae which are connected to each other and enables the backbone to bend.
- (c) • The thoracic vertebrae possess a long spinous process and transverse process for muscle and ligament attachment.
- The thoracic vertebrae have a two-face joint on the transverse process forming a joint with the ribs. This allows the ribs to move up and down. The joints between the thoracic vertebrae and ribs enable the ribs to move up and down when the intercostal muscles contract and relax.
- 7 (a) Muscle P: biceps
Muscle Q: triceps

Tissue X: tendon

Bone Y: humerus

- (b) Inelastic and can be bent
- (c) Movement cannot take place at the joints. Biceps is not attached to radius.
- (d) Milk, because it contains calcium for bone formation and growth.
- (e) When biceps contracts, the pulling force is transferred to the bone through the tendon. This action causes the radius to be pulled up and the arm bends. At the same time, triceps relaxes.

Essay questions

- 8 • The big and long femur adds strength to support body weight.
- Tendon connects muscles to bones.
 - Tendon is tough and inelastic.
 - Ligament supports joints for movement.
 - The hinge joint at the knee, and the ball-and-socket joint at the pelvic girdle produce movements.
 - The quadriceps femoris and the biceps femoris are antagonistic muscles.
 - When the quadriceps femoris or the extensor muscle contracts and the biceps femoris relaxes, the leg is straightened.
 - When the biceps femoris contracts and the quadriceps relaxes, the leg is bent.
 - When the calf muscle contracts, the heel is lifted.
 - At the same time, the foot pushes downwards and backwards.
 - The repetitive contraction and relaxation produces movements.
- 9 Locomotion of an earthworm
- Earthworms have a hydrostatic skeleton.
 - Earthworms move with the aid of hydrostatic pressure changes in the body.

- The circular muscles contract and the longitudinal muscles relax antagonistically.
- This causes the hydrostatic pressure to be transferred from the anterior to the posterior.

Locomotion of a fish

- Possesses endoskeleton
- The fish bone provides surface for muscle attachment.
- The left myotome contracts and the right myotome relaxes antagonistically.
- The tail moves to the left and right producing a push forward.

- 10** (a) • The muscles involved in movement is skeletal muscles. Skeletal muscles produce a voluntary response because they are controlled by the nervous system and can be stimulated under conscious control.
- Skeletal muscles provide the force that is needed to move bones at the joints.
 - Skeletal muscles are unable to push or stretch but can contract and relax.
 - Contraction shortens the skeletal muscle.
 - Relaxation returns the muscle to its original shape and size.
- (b) (i) • The intake of balanced nutrition, for example, taking calcium supplement, phosphate, vitamin A, C and D. Vitamin D aids in calcium absorption and vitamin C increases bone mass.
- Wear comfortable and loose attire.
 - Avoid wearing high-heeled shoes.
 - Exercise and participate in sports regularly.
 - Practise correct and safe exercise techniques to prevent injury to the musculoskeletal system.
 - Always adopt good posture in all daily activities.

- (ii) • Age factor: as a person ages, the density of the bone decreases and subsequently, the bone mass decreases.
- Lack of oestrogen: osteoporosis is more common in menopausal women because the oestrogen level drops after menopause. Oestrogen is involved in calcium metabolism; helps the body absorb calcium and reduce its loss.
 - Lack of exercise: exercise stimulates calcium sedimentation
 - Lack of calcium intake in the diet

- (c) Bending the arm
- At the shoulder, the tendon from one end of the biceps is attached to the scapula (fixed bone) while at the elbows, the tendon at the other end of the biceps is attached to the radius (free-moving bone).
 - The tendon from one end of the triceps is attached to the end of the scapula while the tendon on the other end is attached to the ulna.
 - When bending the arm, the pulling force produced is transmitted to the bone through the tendon. The contraction of the biceps causes the radius to be pulled upwards and the arm is bent.
 - At the same time, the triceps relaxes.

Straightening the arm

- The triceps contracts causing the ulna to be pulled down and the arm is straightened.
- At the same time, the biceps relaxes.

Enrichment

- 11** Hollow bones reduce body weight. They also require less building material such as calcium and phosphorus. The force that can break a long hollow bone is concentrated at the edges of the bone. Therefore, bones that are hollow in the middle are just as strong as compact bones.

12 The bone marrow of birds is porous and not compact. Apart from that, the arrangement of bone cells is also not compact. Therefore, a flying bird's bones are lighter. This reduces the bird's weight and helps it to fly.

- 13**
- The new material must be very light but strong enough to support body weight.
 - The material must also be inexpensive and the patient's body must not reject it.
 - The material used must be biodegradable after the actual bone regrows.

Model Answers

CHAPTER 15 SEXUAL REPRODUCTION, DEVELOPMENT AND GROWTH IN HUMANS AND ANIMALS

Formative Practice 15.1

- 1 Testis, seminiferous tubules, epididymis, vas deferens, seminal vesicle, prostate gland, penis
- 2 The function of seminal vesicle is to secrete nutritious fluid for sperms. Scrotum functions to hold and protect the testis.
- 3 Ovary, Fallopian tube, uterus, cervix, vagina
- 4 The Fallopian tube functions to connect the ovary and uterus, and provides a place for fertilisation. The function of the uterus is to supply nutrients and oxygen to the embryo.

Formative Practice 15.2

- 1 Gametogenesis produces haploid gametes, that is, gametes that contain half the number of chromosomes of the parent cells. When the male and female gamete fuse, the new individual will have the same number of chromosomes as the parent cell (diploid). If gametogenesis does not occur, no gametes will be produced. Hence, fertilisation does not occur. No zygotes will be produced and consequently this leads to the extinction of the particular species.

- 2 (any three differences)

Spermatogenesis	Oogenesis
Occurs in the male testis.	Occurs in the female ovary.
Spermatogonium (diploid) produces four sperms (haploid) after meiosis.	Oogonium (diploid) only yields one functional secondary oocyte cell (haploid) and three non-functional polar bodies after meiosis.

Sperms have a head, middle part and tail.	Ovum is spherical.
After meiosis I, two secondary spermatids are produced.	After meiosis I, a secondary oocyte and a polar body are formed.
Spermatids undergo differentiation to become sperms.	Secondary oocytes do not undergo differentiation.
The formation of sperms is continuous, beginning from puberty until old age	Ovum formation is not a continuous process. It begins in the female foetus and stops when a baby is born. The process is continued only after puberty is reached until menopause.
Millions of sperms are produced each time at any time.	Only one ovum is released from the ovary in each menstrual cycle.

Formative Practice 15.3

1

FSH	• Stimulates oestrogen secretion • Stimulates follicle development in the ovary
LH	• Causes ovulation • Causes the formation of corpus luteum
Oestrogen	• Recovers and repairs endometrial tissues and stimulates the thickening of endometrium • Stimulates follicle development up to maturity • Stimulates secretion of FSH and LH before ovulation

Progesterone

- Stimulates the thickening of the endometrial wall by making it thicker, folded and rich with blood vessels in preparation for implantation of embryo.
- Impedes the secretion of FSH and LH in order to block follicle development and prevent ovulation

- 2 During pregnancy, progesterone prevents uterus contraction and new follicle development as well as induces the enlargement of internal structures such as the ureter and uterus in preparation for carrying a baby to term.
- 3 Corpus luteum degenerates, causing progesterone and oestrogen to stop secreting. Without the stimulation of progesterone and oestrogen, the endometrial wall collapses and menstruation takes place.
- 4
 - Intake of a balanced diet
 - Frequent exercise
 - Positive attitude
 - Get enough sleep
 - Always active

Formative Practice 15.4

- 1 The process of early embryonic development
 - The zygote divides many times by mitosis.
 - The zygote forms a solid ball of cells called morula.
 - Morula forms a hollow sphere known as blastocyst.
 - Blastocyst then develops into an embryo.
- 2 The main function of HCG is to ensure that the corpus luteum continues to function, that is, to produce oestrogen and progesterone in the early stages of pregnancy.

- 3 The placenta functions as an endocrine organ that secretes progesterone and oestrogen. It also serves as the site for material exchange between foetus and mother.
- 4 The placenta is formed from the mother's endometrial tissue and embryonic tissue that allows materials to diffuse across it. If there's a mixture of foetus' and mother's blood, agglutination may occur if the mother's blood group is different from that of the foetus.

Formative Practice 15.5

- 1
 - The genetic constitution and physical characteristics of identical twins are similar whereas for fraternal twins, they are different.
 - The sex of identical twins is the same but may be different for fraternal twins.
- 2 The physical part of Siamese twins is still joined together, usually at the chest, abdomen or pelvis (buttocks). They may also share one or two internal organs.

Formative Practice 15.6

- Hormone imbalance
- Sex organ deformed or infected
- Health issues such as cardiovascular diseases or diabetes
- Immune system

Formative Practice 15.7

- 1 Animal growth can be measured by measuring changes in size, volume, dry mass or wet mass.
- 2 In complete metamorphosis, organisms undergo four stages of growth that is, egg, larva, pupa and adult. In incomplete metamorphosis, organisms undergo several stages of ecdysis before becoming an adult.
- 3
 - Fastest growth rate.
 - Active cellular division and elongation
 - Organism's size increases rapidly

- 4 Insects need to undergo ecdysis, that is, the shedding of the external skeleton to allow growth and development.

Summative Practice 15

- 1 Imbalance of the oestrogen and progesterone levels
- 2 Identical twins are formed when a fertilised ovum divides to form two zygotes whereas fraternal twins are produced when two simultaneously released ova are fertilised by two separate sperms to form two zygotes.
- 3
- To protect the fine blood vessels of the foetus from bursting due to the high blood pressure of the mother
 - To prevent the mother's and foetus blood from mixing which may cause agglutination.
- 4 (a) Both grew up in different conditions. Therefore, their food intake was different and both carried out different daily activities.
- (b)
- Chemicals such as nicotine and carbon monoxide diffuse across the placenta into the foetus.
 - Nicotine may affect foetus growth.
 - Carbon monoxide competes with oxygen to combine with haemoglobin.
 - This reduces the oxygen content received by the foetus and may cause miscarriage.
- 5 The zygote divides repeatedly by mitosis. This cellular division produces a ball of cells, but the cell size is retained at this stage. Further development produces a solid ball of cells called morula. Then the morula will form a blastocyst, a hollow sphere consisting of cells. After a few days, the blastocyst will implant itself on the endometrium (uterine wall) of the mother. This is where the blastocyst continues its development as an embryo. After two months, the embryo is called foetus with most body parts identifiable. The foetus is known as a baby after birth.
- 6
- Level of FSH is low (in the blood).
 - No development of follicle and Graafian follicle is not formed.
 - Less oestrogen secreted (by ovary).
 - Pituitary (gland) is not / less stimulated to secrete (enough) LH.
 - No ovulation.
- 7 (a) Hormone X (FSH) stimulates new follicle development. The lack of hormone X causes no new follicles to be developed.
- (b) Hormone P (oestrogen) restores and repairs the endometrial tissue and stimulates endometrial thickening. Hormone P also causes more hormone Y (LH) to be secreted. The imbalance between these two hormones leads to no ovulation and no thickening of endometrial tissue.
- (c) (i) Structure T is corpus luteum that secretes hormone P (oestrogen) and hormone Q (progesterone). From day 16 to 24, corpus luteum secretes hormone P (oestrogen) and Q (progesterone).
- (ii) On approaching day 24, structure T (corpus luteum) degenerates. Therefore, from day 24 to 28, hormone P (oestrogen) and hormone Q (progesterone) become lesser.
- 8 (a) P – placenta
Q – umbilical cord
- (b)
- The veins in the umbilical cord transport oxygen and nutrient-rich blood from the mother to the foetus.
 - The arteries in the umbilical cord transport blood rich in CO₂ and nitrogenous waste materials such as urea from the foetus to the mother to be expelled.
- (c) Placenta is the site for the exchange of materials between the foetus and the mother. Nutrients, hormones, antibodies and oxygen diffuse from the mother's blood into the foetus.

On the contrary, carbon dioxide and waste materials such as urea, diffuse from the foetus' blood to the mother's. Placenta also replaces the corpus luteum that degenerates during the 4th month of pregnancy to produce progesterone and oestrogen. Both hormones are needed to maintain the thickness of the endometrium throughout pregnancy.

- (d) (i) Natural passive immunity
- (ii) Through P, antibodies diffuse from the mother to the foetus. When the antibodies enter the foetus' bloodstream, the antibodies will act against pathogen. This provide immunity to the foetus and prevents disease infection.

Essay Questions

- 9 • Since the role of hormone X is similar to hormone LH, hormone X is able to stimulate follicle development together with FSH that stimulates ovulation. Therefore, the woman has a possibility of becoming pregnant.
- Ovum is fertilised by sperm to form a zygote.
 - After ovulation, the Graafian follicle forms a corpus luteum.
 - Corpus luteum is stimulated to secrete progesterone and oestrogen.
 - Progesterone and oestrogen stimulate the endometrial tissue to become thick, folded and rich with blood capillaries as a preparation for zygote implantation.
- 10 (a) The testis contains seminiferous tubules that consists of primordial germ cells. Primordial germ cells undergo a series of mitotic divisions to produce many diploid spermatogonia. Spermatogonia grow into primary spermatocytes. Each primary spermatocyte then divides by meiosis I to produce a pair of secondary spermatocytes which are haploid. Each pair of secondary spermatocytes will divide by meiosis II to produce four haploid

spermatids. Finally, spermatids differentiate to become sperms.

- (b) (i) R: Siamese twins: Identical twins

Similarities:

- An ovum is fertilised by a sperm to form a zygote.
- Both twins have the same genetic constitution.
- Both twins are of the same sex, that is, both are either boys or girls.

Differences:

- For twins S, blastocyst divides completely into two, but in twins R, complete division did not occur.
- Twins S are separated from each other fully, but twins R are attached at certain parts of the body.

Enrichment

- 11 To fertilise an ovum, the protective layer outside the ovum must be digested by the enzyme found in the sperm acrosome. Therefore, one sperm is not enough to digest the protective layer. The presence of many sperms is sufficient to digest the protective layer to enable one sperm to fertilise the ovum.
- 12 For an individual with a 28-day menstrual cycle, the changes in the levels of various hormones in preparation of conception is shown below.
- From day 0 to 7, right after menstruation, the pituitary gland is stimulated to secrete follicle stimulating hormone (FSH).
 - FSH causes one or more Graafian follicle to develop in the ovary.
 - FSH stimulates follicle cells to secrete oestrogen.
 - From day 8 to 14, the concentration of oestrogen increases and reaches its maximum level on day 12.
 - Oestrogen acts to restore and repair the endometrial tissue.

- Oestrogen also stimulates the pituitary gland to secrete luteinising hormone (LH).
- LH stimulates ovulation on day 14.
- From day 15 to 21, the Graafian follicle that develops into a corpus luteum will be stimulated by LH to secrete progesterone.
- The rising progesterone level stimulates the endometrium to expand, become thicker and more vascular.
- From day 22 to 28, if fertilisation occurs, the progesterone level will continue rising to ensure further uterine development.

- Progesterone inhibits FSH and LH production, hence the menstrual cycle and ovulation does not take place in a woman who is pregnant. This will prevent the development of other follicles in the ovary during pregnancy.

13 The stem cells of the umbilical cord have the potential to be turned into various types of cells. Therefore, umbilical cord stem cells can be used to treat various life-threatening diseases such as heart attack and stroke. Stem cell bank is one way of keeping umbilical cord blood so that the concerned individual can get their own stem cell for cellular therapy in the future.