SACE STAGE 1
Australian Curriculum

WORKBOOK

Biology

TOPICS

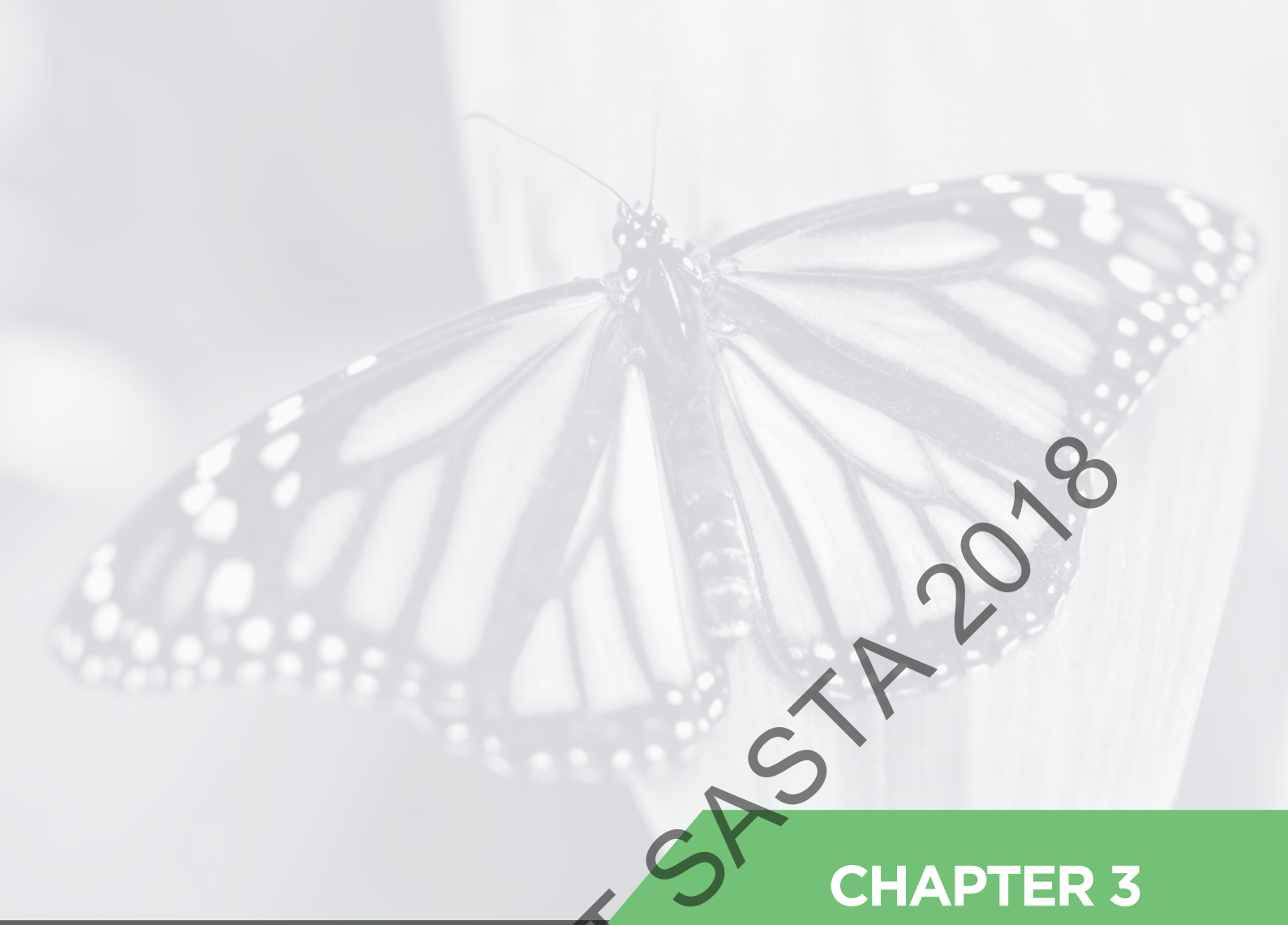
> Cells and microorganisms
> Infectious disease
> Multicellular organisms
> Biodiversity and ecosystem dynamics

SASTA
South Australian Science Teachers Association

Supporting Teachers of Science
Advancing Science Education

SECOND EDITION
Rhys Lewis

Contents



CHAPTER 3

3.1: Cell specialisation

Specific cell structure and functions develop through cell differentiation.

- Recognise that cells in a multicellular organism are genetically identical.
- Recognise that gene expression is responsible for cell specialisation.

A **multicellular organism** is a living thing that is composed of more than one cell including plants, animals and multicellular fungi. Life processes in a multicellular organism are carried out by different cell types that have a specialised structure and function. The human body contains over 200 specialised cell types and some of these are shown in Figure 3.01.

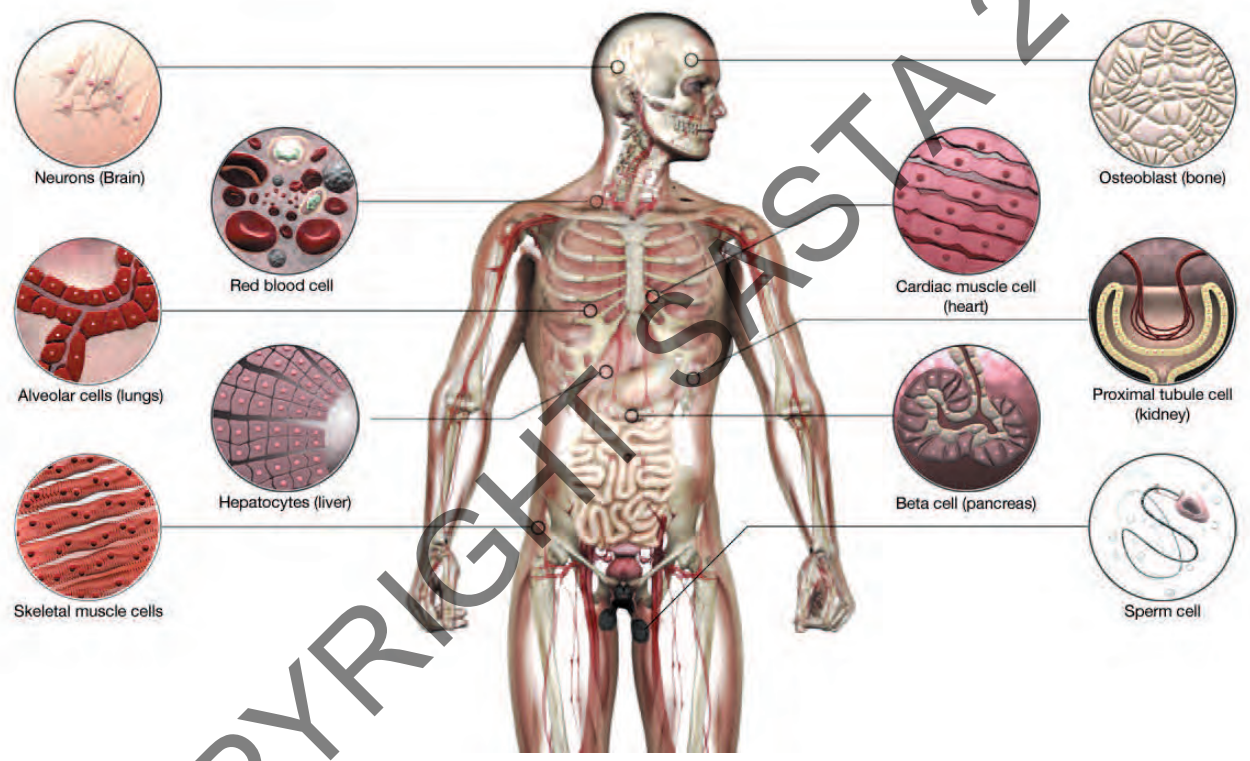


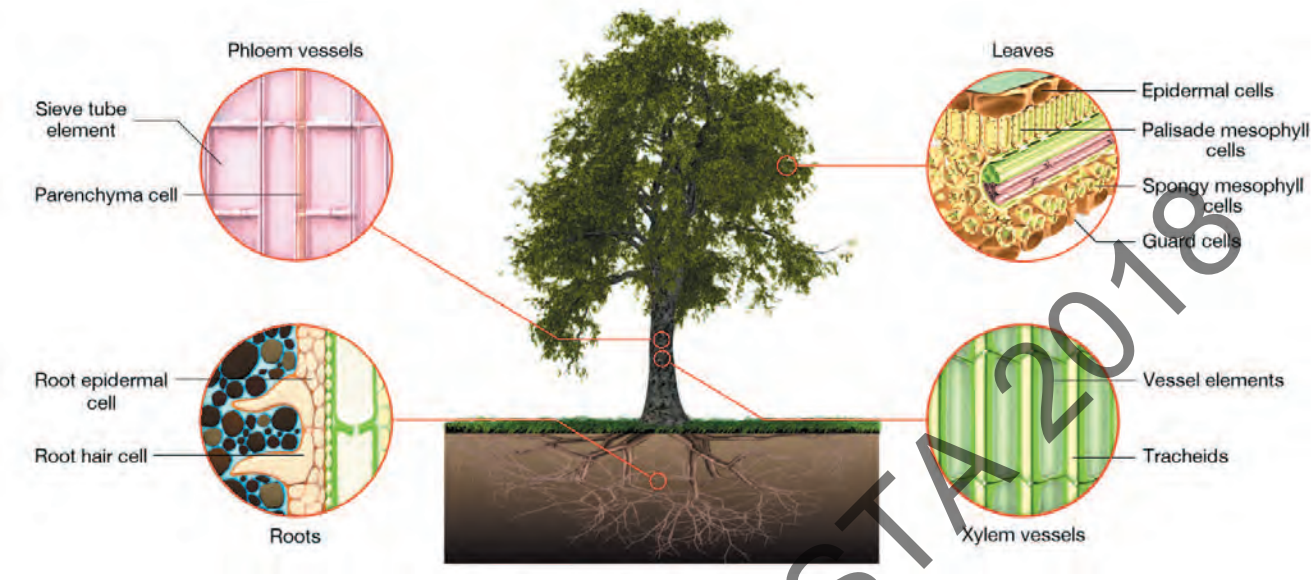
Figure 3.01: Specialised cell types in the human body.

The functions of some specialised cell types in the human body are identified in the table below.

Cell type	Function
Nerve cell	Respond to stimuli by transmitting nerve impulses to the brain.
Red blood cell	Transports oxygen and glucose to cells for respiration.
White blood cell	Defend the body against pathogens and cancer cells.
Sperm and egg cells	Combine to produce offspring in the process of reproduction.
Muscle cells	Contract and relax to allow movement of the body and its organs.
Liver cells	Metabolise fats, carbohydrates and proteins.

Question 51

The diagram below shows the different cell types in a tree.



(a) Define the term multicellular organism using a tree as an example.

_____

_____ (1 mark) **KA1**

(b) Palisade mesophyll cells and epidermal cells are differentiated cells in the leaves of plants.

(1) Define the term differentiated cell.

_____

_____ (1 mark) **KA1**

(2) The nucleus of a palisade mesophyll cell has approximately 40 000 genes.

State the number of genes in an epidermal cell.

_____ (1 mark) **KA1**

(3) Palisade mesophyll cells and epidermal cells have different structures and functions.

Explain why there is a difference in structure and function of these two cell types.

_____

_____

_____

_____

_____ (2 marks) **KA1**

3.2: Tissues, organs, and systems

Multicellular organisms have a hierarchical structural organisation of cells, tissues, organs, and systems.

Organ systems in a multicellular organism are interdependent and function together to ensure the survival of the organism.

Lifestyle choices affect the functioning of organs and systems.

- Use examples from plants and animals to explain the organisation of cells into tissues, tissues into organs, organs into systems.
- Illustrate the relationship between the structure and function of cells, tissues, organs, and systems.

Multicellular organisms have a hierarchy of structure and organisation that consists of cells, tissues, organs and organ systems. The structural hierarchy is described in the table below.

Level	Description
Cell	The basic unit of structure and function in a multicellular organism.
Tissue	A group of differentiated cells that have a similar structure and function.
Organ	A group of tissues that have been adapted to perform a specific function.
Organ system	A group of organs that work together to carry out a specific function.

Example 3.01

The digestive system is an organ system in animals that is composed of several organs including the oesophagus, stomach, small intestine, large intestine and liver that work together to carry out digestion and the absorption of nutrients from food. The hierarchy of structure in the digestive system is summarised in Figure 3.03.

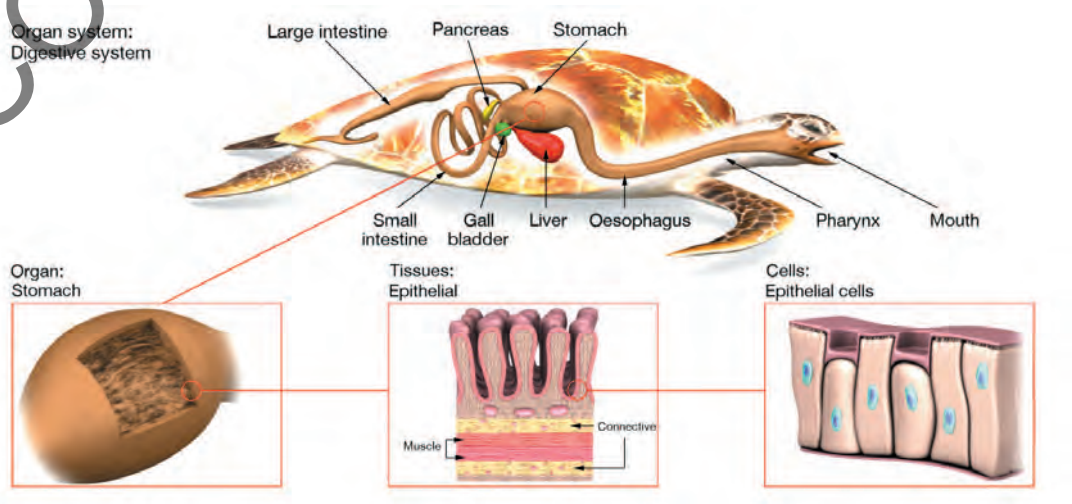


Figure 3.03: Hierarchy of structure in the digestive system

Tissues

Multicellular organisms including plants and animals have specialised **tissues** that organise and regulate life processes including movement, metabolism, excretion and responding to stimuli. Tissues consist of differentiated cells and fibres that have a similar structure and function.

Plant Tissues

More than 90% of plant species on Earth are classified as **vascular plants**. Vascular plants are land plants that have specialised tissues for transporting water and minerals. The three kinds of tissues found in vascular plants are **dermal**, **vascular**, and **ground** tissues (Figure 3.04).

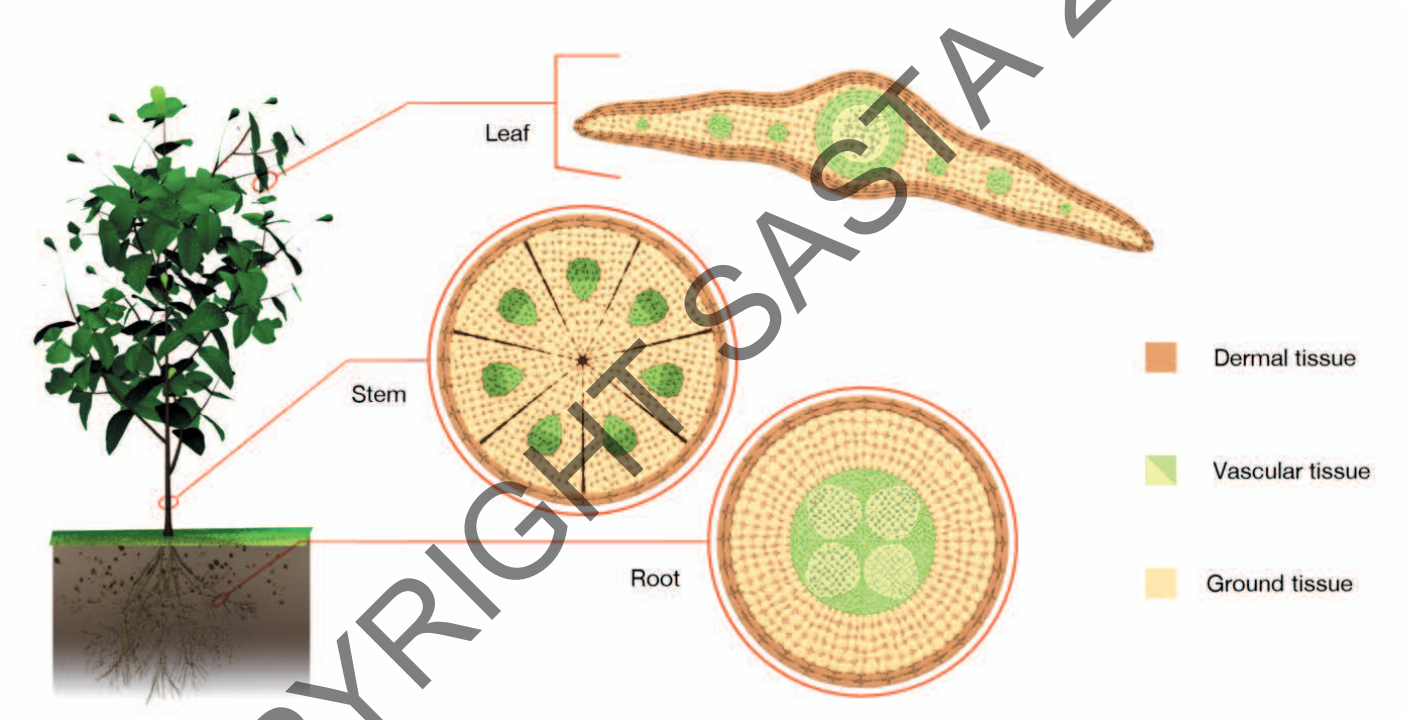


Figure 3.04: Tissue types in vascular plants.

The primary functions of the three tissue types are identified in the table below.

Tissue	Cells present	Primary function(s)
Dermal	Epithelial cells, guard cells	Prevent water loss and invasion by insects and microorganisms.
Vascular	Tracheids, vessel elements, sieve tube elements.	Transports water, sugars, hormones and minerals.
Ground	Mesophyll cells	Stores nutrients, perform photosynthesis and provides structural support for vascular tissue.

Animal Tissues

Animals are classified as vertebrates and invertebrates depending on whether the animal has a vertebral column or backbone. More than 90% of all animal species are invertebrates. The four kinds of tissues found in vertebrates and invertebrates are **epithelial**, **connective**, **muscle** and **nervous** tissues. Figure 3.05 shows the four tissue types in the human body (vertebrate).

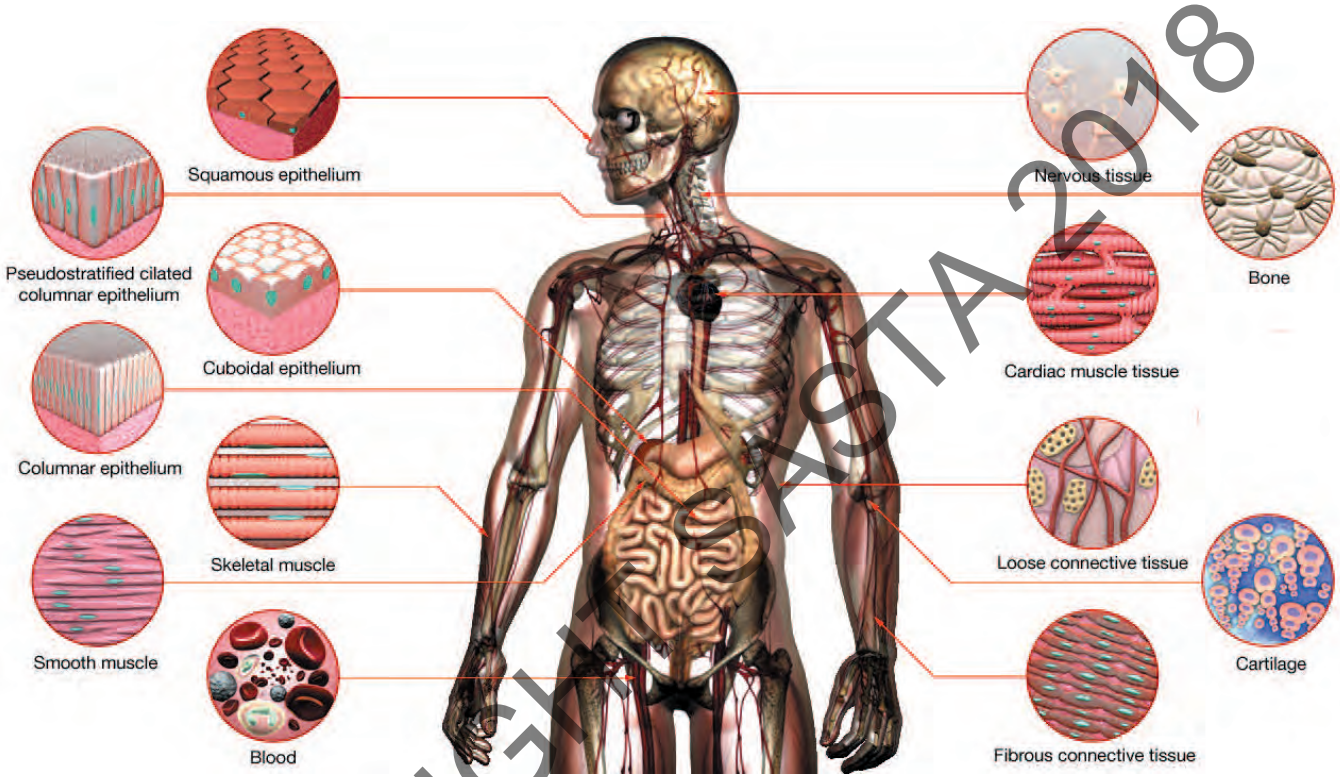


Figure 3.05: Tissue types in the human body.

The primary functions of the three tissue types are identified in the table below.

Tissue	Cells present	Primary function(s)
Epithelial	Epithelial cells, goblet cells	Protection against infection, fluid loss, and injury. Facilitate the absorption of gases and nutrients.
Connective	Red blood cells, white blood cells, fat cells, bone cells.	Connects and supports organs, transports materials around the body, stores energy and fights infection.
Muscle	Skeletal muscle, smooth muscle, and cardiac muscle.	Provides structural support to the body, movement, and generating heat.
Nervous	Neurons and glial cells.	Responds to environmental and internal stimuli and transmits nerve impulses that control movement.

Organ systems

An organ system is a group of organs and tissues that work together to perform one or more functions in the body of a multicellular organism.

Plant organ systems

Vascular plants have two organ systems called the **shoot system** and **root system**. The shoot system is above ground and includes the stem, leaves and reproductive organs, and the root system is below ground and is composed of different types of roots.

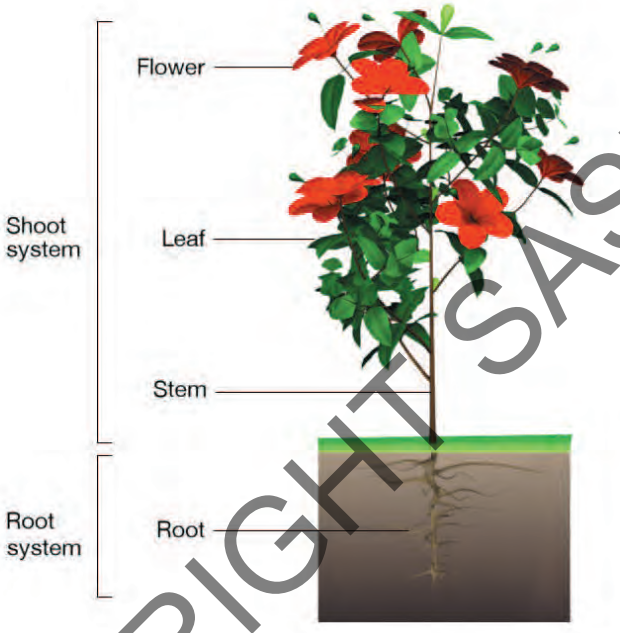


Figure 3.08: Shoot and root system in a vascular plant.

The functions of the shoot and root systems in a plant are identified in the table below.

Organ	Organs present	Primary function(s)
Shoot	Stem, leaves and reproductive organs (flowers and fruit)	• Carry out photosynthesis; • Carry out sexual reproduction; • Transport water and minerals to leaves and reproductive organs.
Root	Roots	• Absorption of water and nutrients from soil; • Anchoring of the plant body to the soil; • Storing nutrients; • Forms symbiotic relationships with bacteria and fungi to support life processes.

Animal organ systems

Animals have many organ systems that carry out life processes essential to the survival and reproduction. Humans have 11 organ systems including the endocrine (hormonal), immune, integumentary, muscular, skeletal, nervous, digestive, circulatory, respiratory, urinary, and reproductive systems (Figure 3.09).

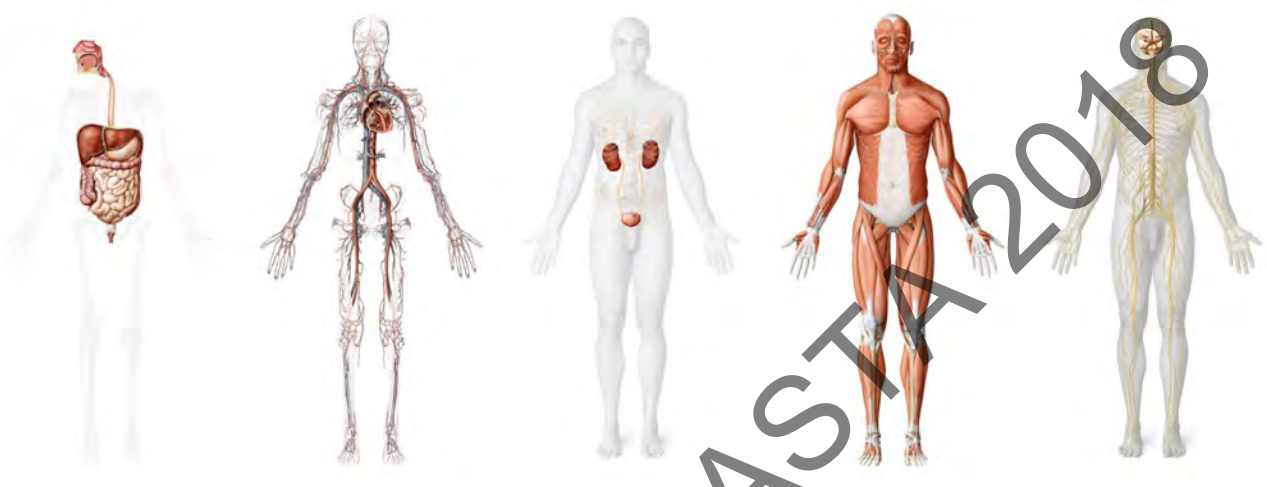


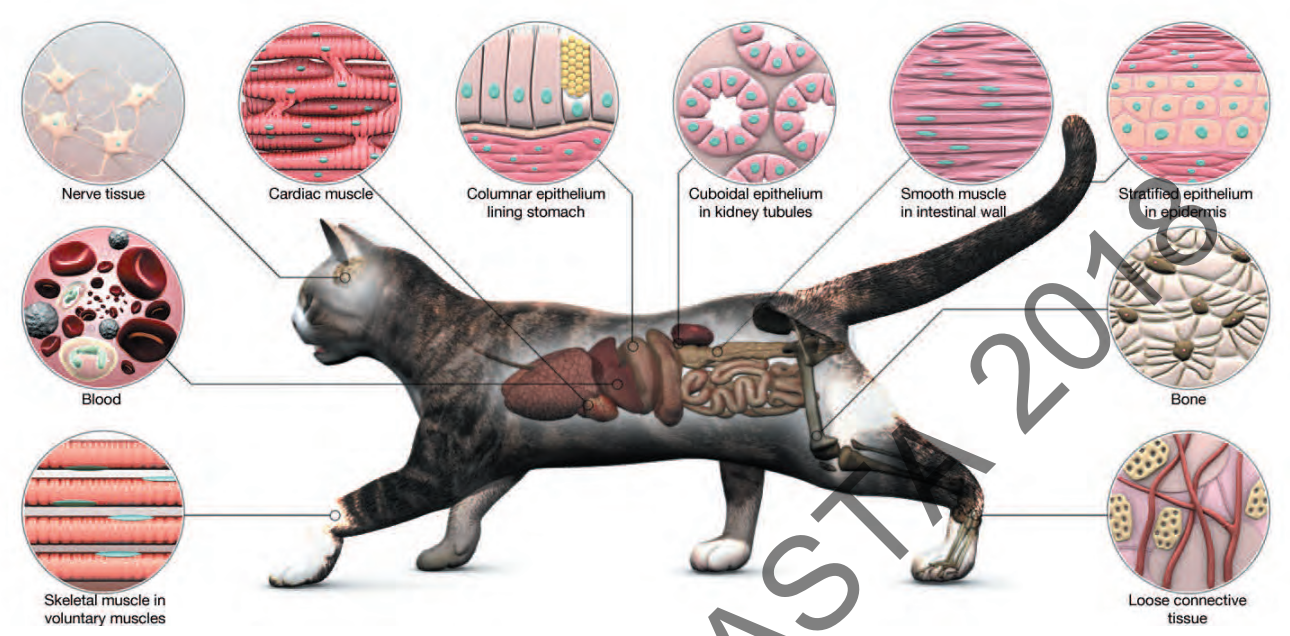
Figure 3.09: Human body systems (digestive, circulatory, urinary, muscular, nervous).

The functions of some organ systems in animals are identified in the table below.

Organ	Organs/tissues present	Primary function(s)
Digestive	Oesophagus, stomach, intestines, liver.	• Digestion of food and absorption of nutrients.
Circulatory	Heart, arteries, veins	• Transports oxygen and glucose to tissue cells.
Urinary	Kidneys, bladder	• Producing and excreting urine.
Muscular	Skeletal muscle, cardiac muscle, and smooth muscle.	• Movement, posture, and balance.
Nervous	Brain, sensory organs and nervous tissue.	• Sensing and responding to stimuli.
Respiratory	Bronchi, bronchioles, diaphragm, lungs.	• Absorption of oxygen and the removal of carbon dioxide from the body.
Immune	Skin, thymus, spleen, connective tissue.	• Defence against infectious disease.
Skeletal	Connective tissues (bones cartilage, ligaments, tendons).	• Provides a structural framework for the body.

Question 52

The diagram below shows the position of some organs and tissues in the body of a domestic cat.



(a) Cats and other mammals contain three types of muscle tissue.

(1) Define the term tissue using skeletal muscle tissue as the example.

_____

_____ (1 mark) **KA1**

(2) Identify the type of muscle tissue present in the walls of the stomach and intestines.

_____ (1 mark) **KA1**

(3) State two functions of muscle tissue in mammals.

_____

_____ (2 marks) **KA1**

(b) Blood is an example of connective tissue in animals.

(1) State the primary function of blood in animals.

_____

_____ (1 mark) **KA1**

(2) Name one other type of connective tissue present in the diagram above.

_____ (1 mark) **KA1**

Gas exchange in animals

Animals have gas exchange systems that facilitate the diffusion of oxygen into the body for aerobic respiration as well as the removal of carbon dioxide.

Example 3.05

Flatworms are invertebrate animals with no specialised circulatory and respiratory organs to extract oxygen from the environment. Instead, flatworms use their outer body surfaces to exchange oxygen and carbon dioxide as illustrated in Figure 3.12.

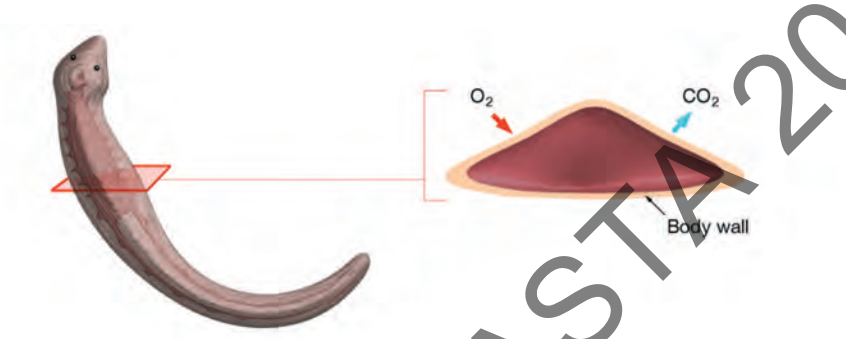


Figure 3.12: Gas exchange in flatworms.

Flatworms have a thin body wall that reduces the length of the diffusion path, an elongated body that increases surface area to volume ratio for gas exchange, a moist outer body surface, and a primitive circulatory system that maintains the concentration gradients of different gases.

Example 3.06

Insects are invertebrate animals with a hard exoskeleton that is unsuitable for gas exchange. Instead, gases are exchanged through small pores called **spiracles** in the body of an insect, and these are connected to internal gas exchange surfaces called **tracheoles** (Figure 3.13).

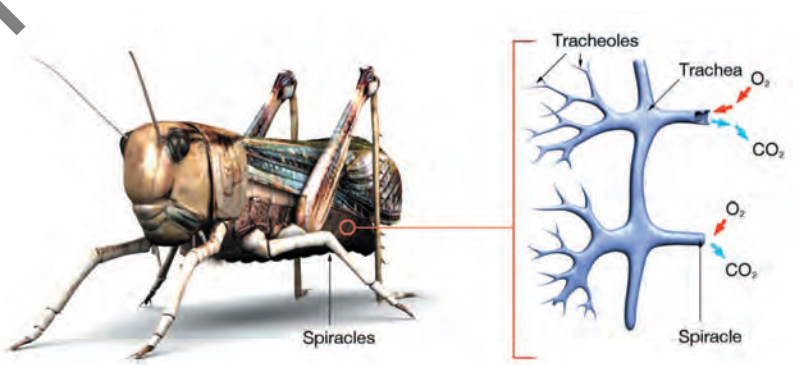


Figure 3.13: Gas exchange in insects.

The tracheoles are thin and filled with fluid that allows gases to dissolve and diffuse into tissues more efficiently. Furthermore, the extensive network of tracheoles greatly increases the surface area to volume ratio for gas exchange with body tissues.

Example 3.07

Fish are vertebrate animals that rely on specialised flaps of tissue called **gills** for gas exchange with their surroundings (water). Oxygen dissolved in fresh and saltwater diffuses into the body of a fish through gills where it enters the circulatory system and is transported to cells and tissues for respiration (Figure 3.14).

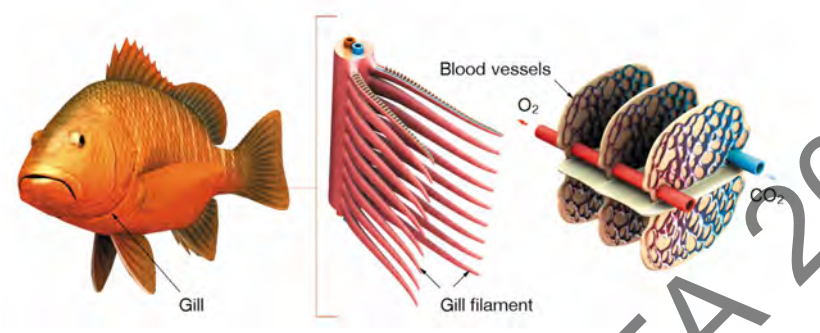


Figure 3.14: Gas exchange in fish.

Gills have numerous folds that create a large surface area to volume ratio for efficient gas exchange. The constant flow of blood through blood vessels maintains the concentration gradients of oxygen and carbon dioxide through the circulatory system.

Example 3.08

Mammals are vertebrate animals that use lungs for the extraction of oxygen from air and the removal of carbon dioxide from the body. The lungs contain specialised gas exchange surfaces called **alveoli** that facilitate the exchange of gases between the lungs and circulatory system (Figure 3.15).

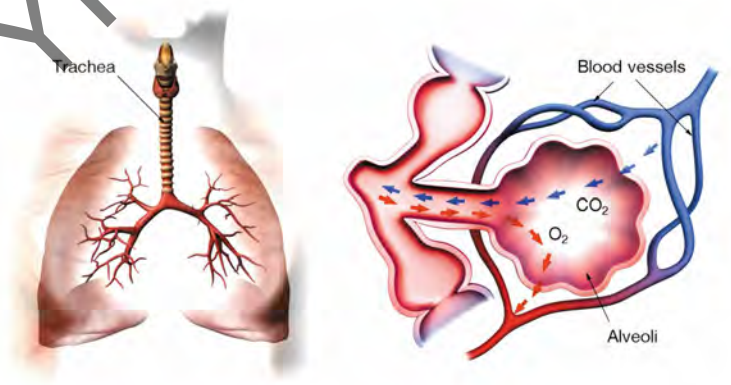


Figure 3.15: Gas exchange in mammals.

The lungs of mammals have a very large surface area to volume ratio due to the hundreds of millions of alveoli as well as a highly developed circulatory system that maintains the concentration gradients of oxygen and carbon dioxide in the body. The alveoli are lined with a single thin layer of epithelial cells that shortens the distance for the diffusion of gases between the lungs and circulatory system. The epithelial cells are lined with fluid that enables the rapid passive diffusion of gases into blood.

Ventilation

Ventilation (breathing) is the process by which air flows between the atmosphere and the lungs due to a difference in air pressure. Ventilation consists of two stages called **inspiration** (inhalation) and **expiration** (exhalation).

Inspiration is the process of moving air into the lungs.

1. The intercostal muscles move the ribcage upwards and outwards causing the chest to expand.
2. The diaphragm contracts and flattens which increases the volume of the lungs and decreases the air pressure inside the lungs.
3. Air flows from the atmosphere (higher pressure) to the lungs (lower pressure).

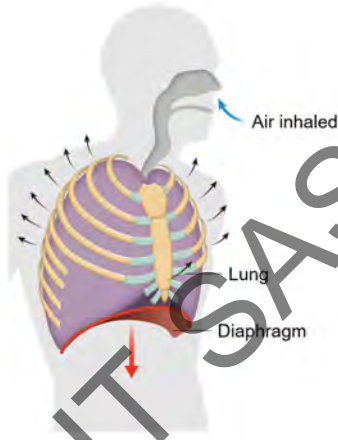


Figure 3.18: Inspiration (inhalation).

Expiration is the process of moving air out of the lungs.

1. The intercostal muscles move the ribcage downwards and inwards causing the chest to contract.
2. The diaphragm relaxes and moves upwards which decreases the volume of the lungs and increases the air pressure inside the lungs.
3. Air flows from the lungs (higher pressure) to the atmosphere (lower pressure).

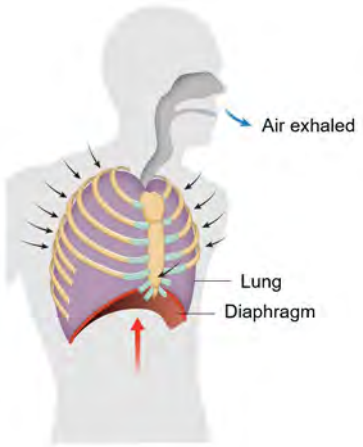
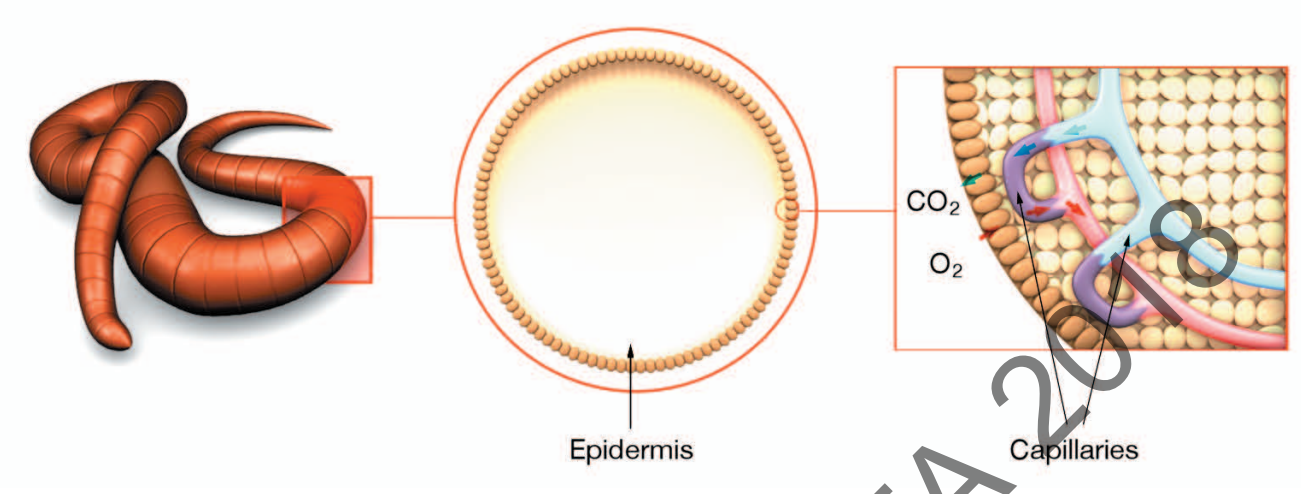


Figure 3.19: Expiration (exhalation).

Question 56

The diagram below illustrates the gas exchange system of an earthworm (*Lumbricus terrestris*).



(a) Gases are exchanged between the epidermis of an earthworm and its environment.

(1) State the property of the epidermis that enables efficient gas exchange.

_____ (1 mark) **KA2**

(2) Name the waste gas excreted into the soil through the epidermis.

_____ (1 mark) **KA1**

(b) Earthworms are behaviourally adapted to stay in moist soil during the day.

Explain how this adaptation enables efficient gas exchange with the soil.

_____

_____

_____

_____ (2 marks) **KA2**

(c) State why earthworms try to avoid exposure to sunlight.

_____

_____ (1 mark) **KA2**

(d) Soil contains oxygen that earthworms use for respiration.

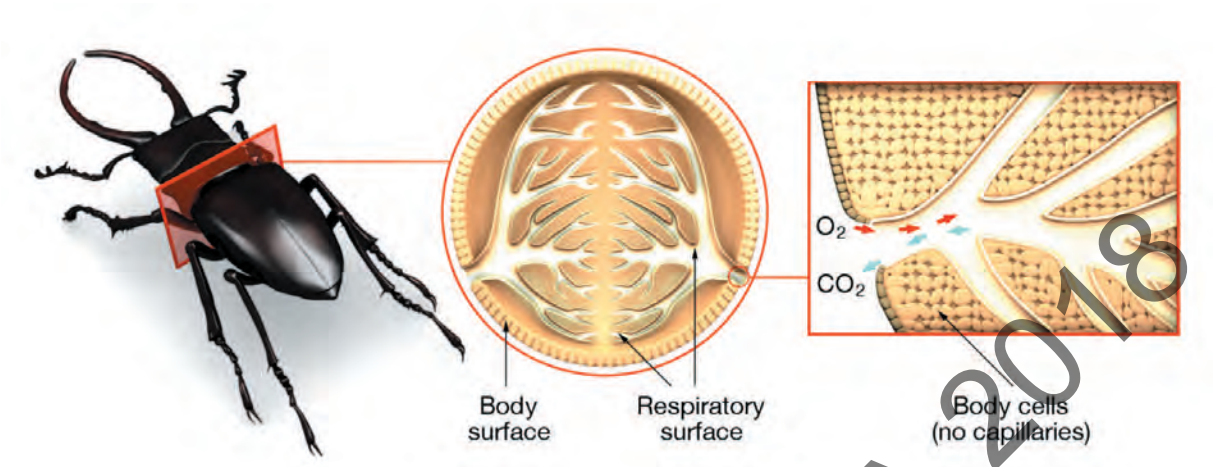
State a reason why earthworms often crawl to the soil surface following periods of heavy rain.

_____

_____ (1 mark) **KA2**

Question 57

The diagram below is an illustration of the respiratory system of an insect.



(a) The respiratory system contains an extensive network of tracheoles.

State the feature of tracheoles that enables efficient gas exchange.

_____ (1 mark) **KA2**

(b) The trachea and tracheoles are always filled with water vapour.

(1) State the function of water vapour in gas exchange.

_____

_____ (1 mark) **KA1**

(2) State why insects close their spiracles when resting.

_____

_____ (1 mark) **KA2**

(c) Lactic acid accumulates in tissues when respiration is high.

(1) State the type of respiration that produces lactic acid in animals.

_____ (1 mark) **KA2**

(2) Describe and explain how the accumulation of lactic acid increases the rate at which oxygen is supplied to tissues.

_____

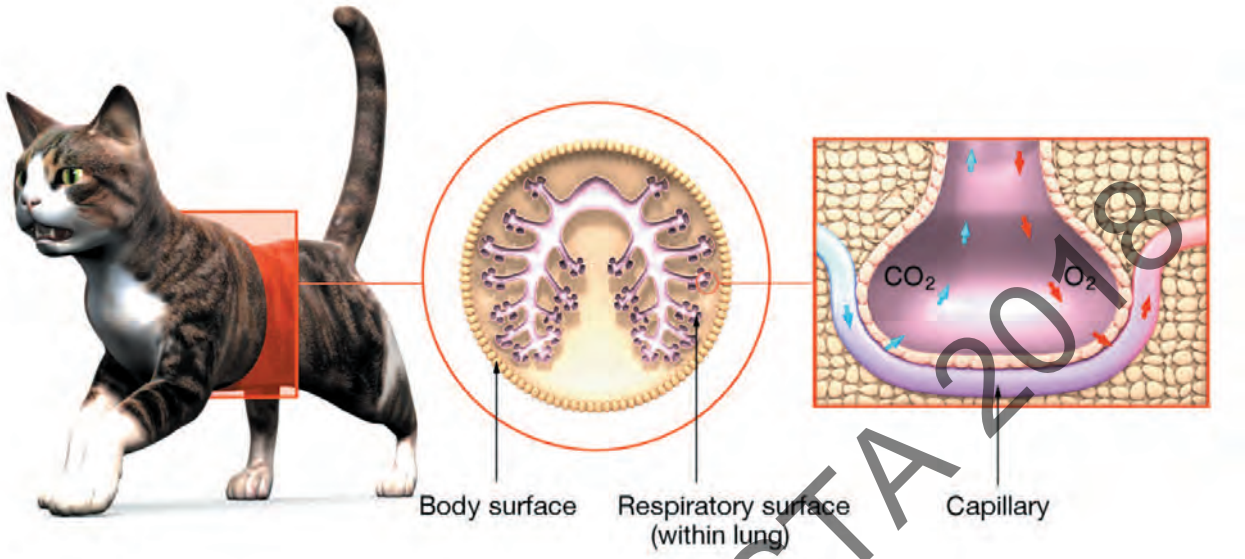
_____

_____

_____ (2 marks) **KA2**

Question 58

The diagram below is an illustration of the respiratory system of a mammal.



(a) State the source of carbon dioxide diffusing into alveoli.

_____ (1 mark) KA2

(b) Describe two features of alveoli that enable efficient gas exchange in mammals.

_____

_____

_____

_____ (2 marks) KA2

(c) Describe differences in the composition of air in the alveoli before inspiration and expiration.

_____

_____

_____

_____ (2 marks) KA2

(d) State one reason why blood flowing away from the alveoli still contains carbon dioxide.

_____

_____

_____ (1 mark) KA2

3.4: Gas exchange in plants

In plants, gas exchange is facilitated by the structure of the leaf.

Gases are exchanged mainly via stomata. Their movement within the plant is by diffusion and does not involve the plant transport system.

Describe and explain how gases move into, through, and out of plants.

- Describe the loss of water through open stomates.

Plants exchange gases with the soil and atmosphere including oxygen, carbon dioxide and water vapour. The exchange of gases in plants is facilitated primarily by leaves and roots.

Leaves

Leaves are flattened organs that grow outwards from the stems of vascular plants. Leaves are composed of dermal, vascular and ground tissue, and each is composed of differentiated cells that carry out one or more functions. Figure 3.20 shows the position of the three tissue types in a leaf.

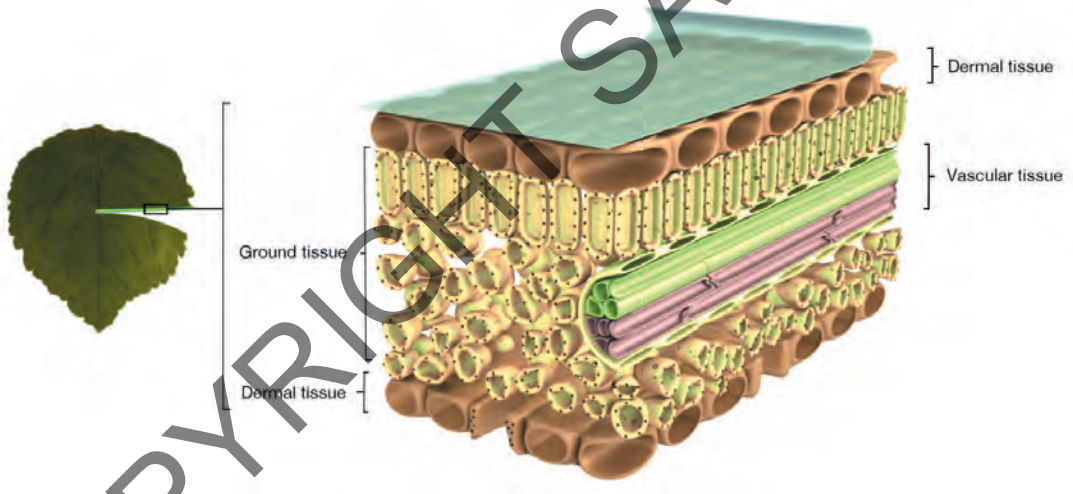


Figure 3.20: Exchange of gases between the atmosphere and plant leaves.

The primary functions of the different tissue types in a plant leaf are summarised in the table below.

Tissue	Primary function(s) in leaves
Dermal	Prevent water loss and invasion by insects and microorganisms.
Vascular	Transports water and minerals to leaves for photosynthesis and transpiration. Transports sugars produced in leaves to stems and roots for aerobic respiration.
Ground	Contains mesophyll cells that carry out photosynthesis.

Gas exchange in leaves

The primary function of a leaf is to absorb light and produce glucose and other essential nutrients through photosynthesis.

	carbon dioxide	+	water	→	glucose	+	oxygen

The nutrients produced by photosynthesis are transported around the body of a plant where they sustain life processes in cells including respiration, metabolism and growth.

Leaves are one of the sites of gas exchange in plants. Carbon dioxide (CO_2) diffuses into leaves from air and oxygen diffuses out as shown in Figure 3.21. The exchange of carbon dioxide and oxygen between leaves and the atmosphere occurs through small pores called **stomata** (singular: **stoma**).

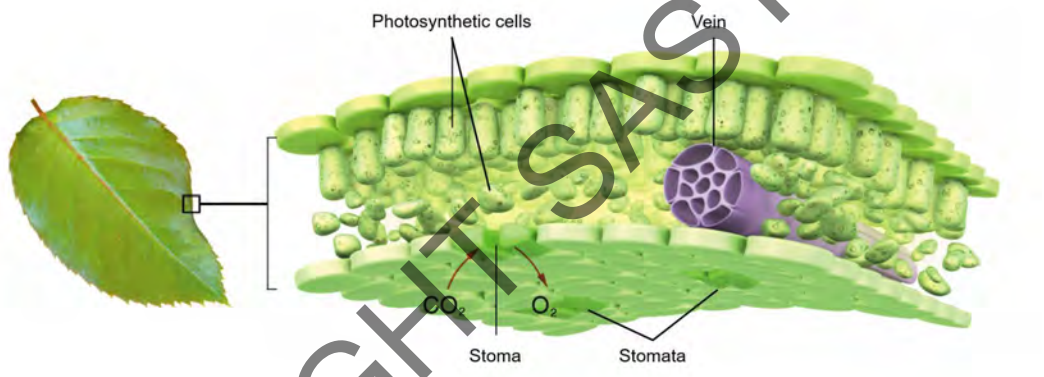


Figure 3.21: Exchange of gases between the atmosphere and plant leaves.

Each stoma is surrounded by two differentiated cells called **guard cells**. Guard cells contain protein receptors that are activated by sunlight. The absorption of sunlight by receptor proteins causes membrane channel proteins to open, and both potassium and chloride ions diffuse into guard cells. Water then diffuses into guard cells by osmosis causing guard cells to swell and become turgid which exposes stomata and allows gases to diffuse between the atmosphere and leaf (Figure 3.22).

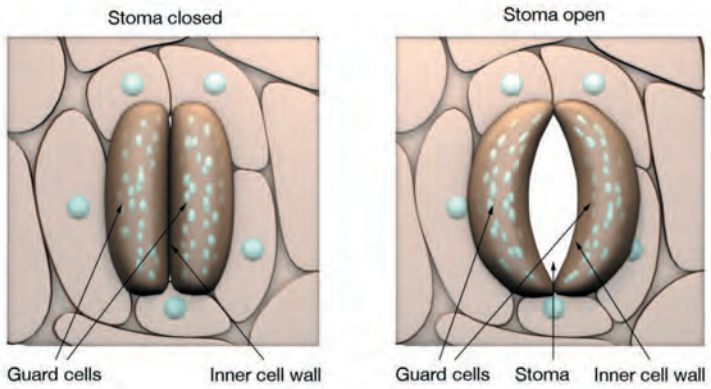


Figure 3.22: Positions of guard cells when stoma is closed (left) and open (right).

Gas exchange surfaces in leaves

The exchange of carbon dioxide and oxygen is between **mesophyll cells** in ground tissue and the surrounding air spaces. Leaves contain two types of mesophyll cells called **palisade mesophyll cells** and **spongy mesophyll cells,** and each contains chloroplasts that absorb light and carry out the process of photosynthesis. Figure 3.23 shows the gas exchange surface inside a leaf.

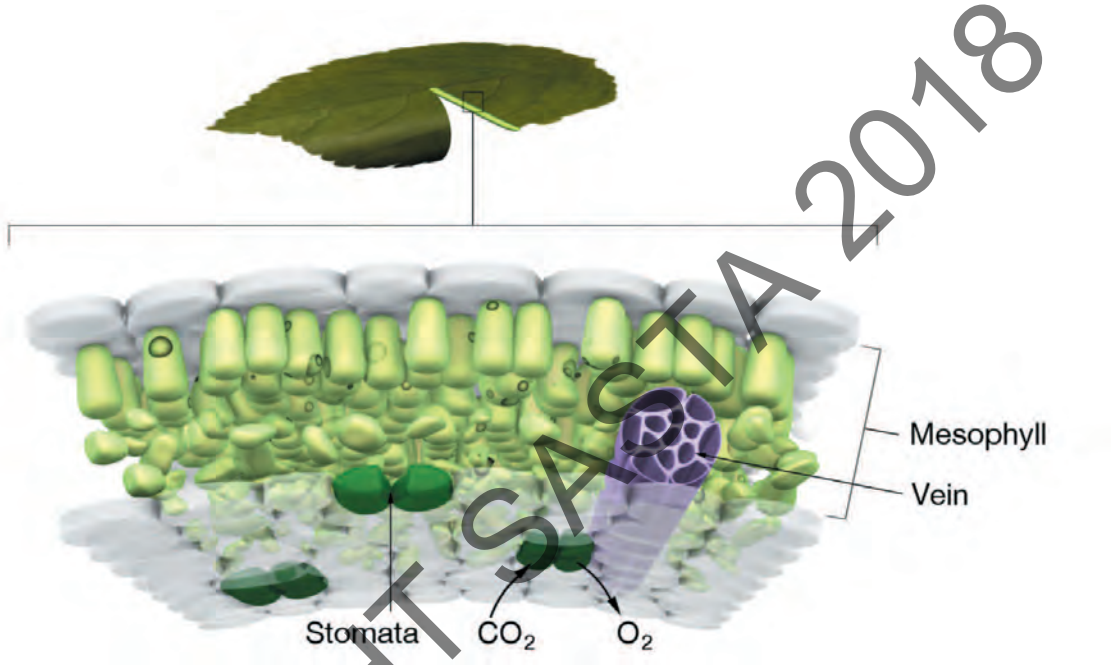


Figure 3.23: Gas exchange surface in a leaf.

The gas exchange surface has several properties that increase the rate at which gases diffuse between mesophyll cells and the surrounding air spaces inside a leaf.

Property	Description
Thin cell walls	The cell walls of mesophyll cells are thin which reduces the diffusion path for gases.
Large air spaces	The air spaces surrounding mesophyll cells are large which increases the surface area to volume ratio for gas exchange.
Moisture	The surfaces of mesophyll cells are moist which increases the efficiency of gaseous diffusion.
Short diffusion path	Mesophyll cells are in direct contact with the air spaces which reduces the diffusion path for gas exchange.

Transpiration

Transpiration is the process by which water moves through the organs and is evaporated through the aerial parts of the plant including the stem and leaves (Figure 3.24).

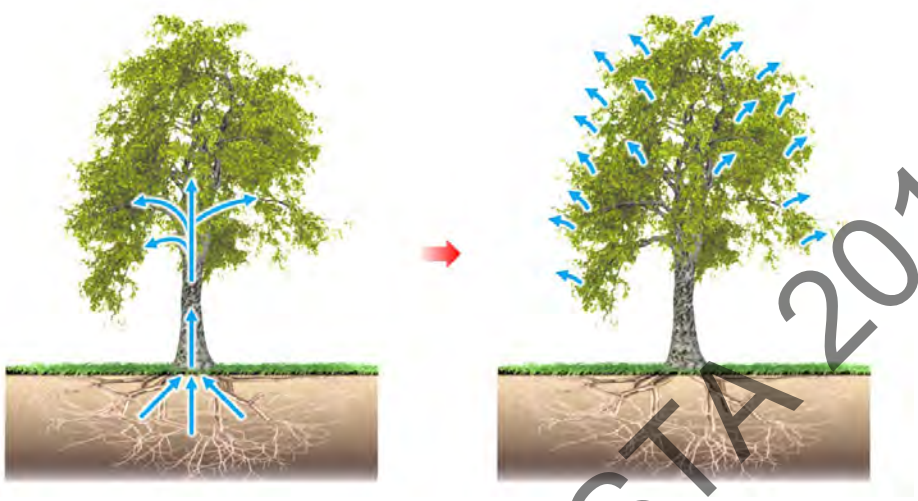


Figure 3.24: Transpiration.

Water diffuses into a plant through the roots and is transported to the stem and leaves inside vascular tissue. A small quantity of the water (<5%) diffuses into plant cells and is used in metabolism, respiration, photosynthesis and growth, and the remainder diffuses into the atmosphere through stomata in leaves (Figure 3.25).

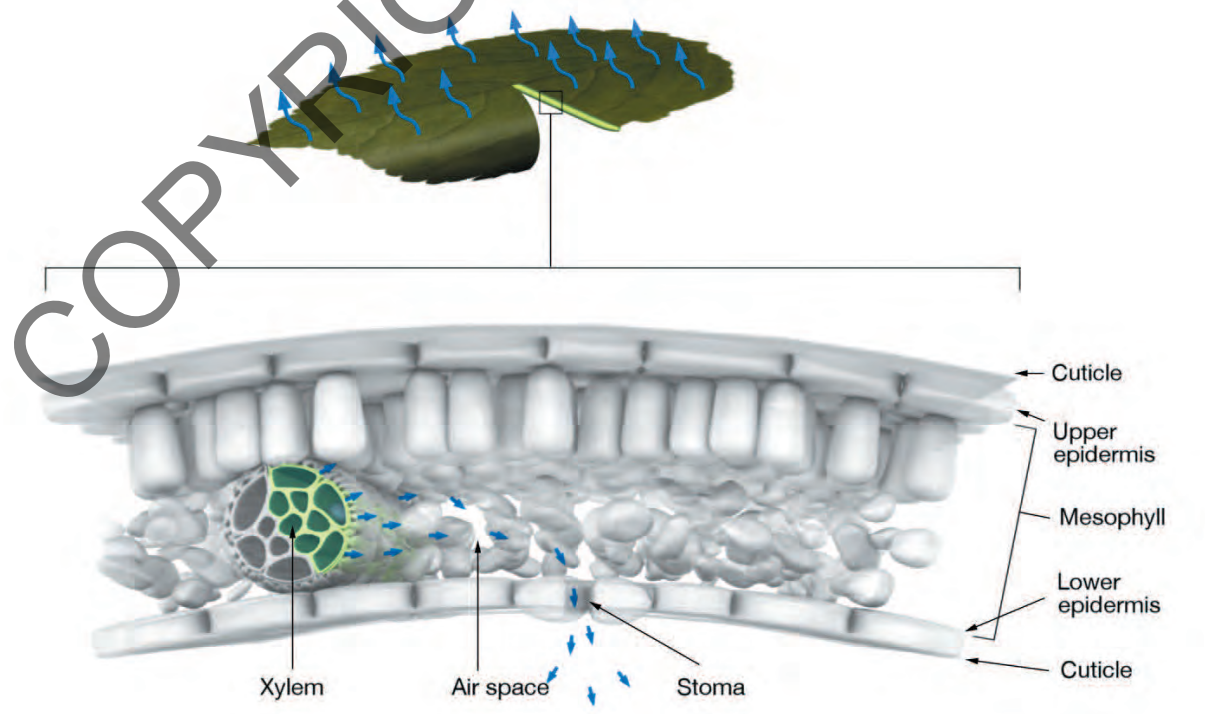
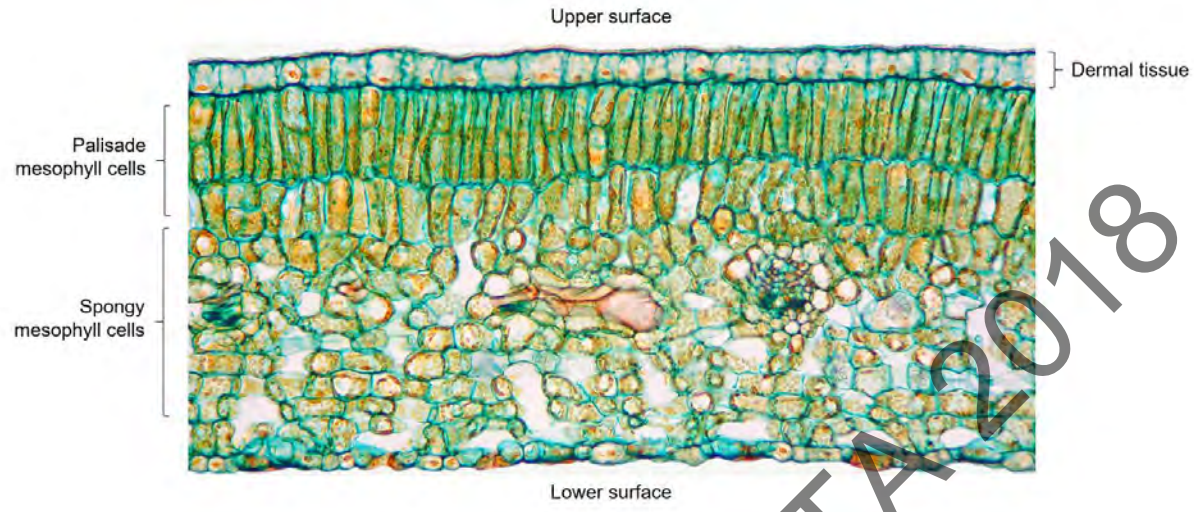


Figure 3.25: Diffusion of water into the atmosphere through stomata.

Question 63

The diagram below is a light micrograph of the leaf of a tea plant (*Camellia sinensis*).



(a) Photosynthesis occurs in palisade and spongy mesophyll cells.

State why palisade mesophyll cells contain more chloroplasts than spongy mesophyll cells.

_____

_____ (1 mark) **KA2**

(b) State the advantage of dermal tissue in the tea plant having a thickness of one cell.

_____

_____ (1 mark) **KA2**

(c) Gases are exchanged between mesophyll cells and the surrounding air spaces.

(1) Name two gases that are exchanged between mesophyll cells and the air spaces.

_____ (2 marks) **KA1**

(2) Describe three features of the leaf that improve the efficiency of gas exchange between mesophyll cells and the surrounding air spaces.

_____

_____

_____

_____

_____

_____ (3 marks) **KA1**

3.5: Nutrient exchange in animals

In animals, the digestive system is responsible for the breakdown of food and absorption of nutrients required for survival.

- Relate the structure of organs of the digestive system to their function.
- Describe the structure and function of villi in the human digestive system.

Multicellular organisms require a source of nutrients for metabolism, respiration and growth. Plants are autotrophs that synthesise many important nutrients through photosynthesis, whereas animals are heterotrophs that obtain nutrients from materials derived from other living things.

Digestion

Food is a complex mixture of proteins, carbohydrates and lipids that animals absorb and break down to obtain nutrients for metabolism, respiration and growth. The process by which animals extract nutrients from food occurs in four stages that are summarised in Figure 3.26.

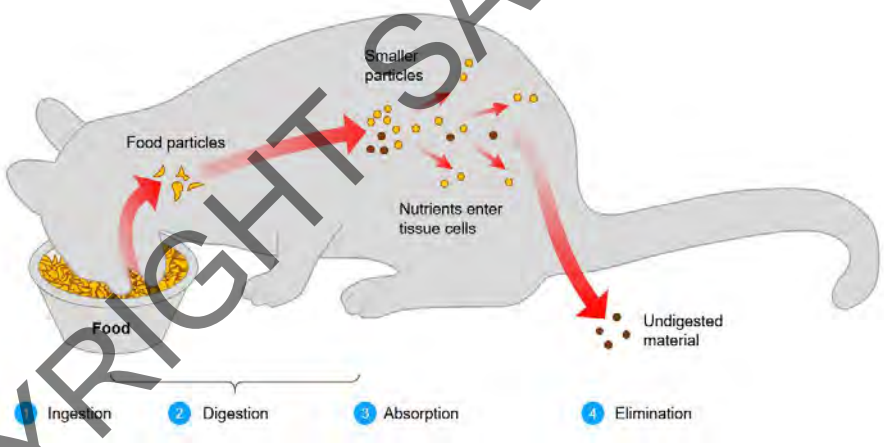


Figure 3.26: Stages of food processing in animals.

Stage	Description
Ingestion	Food is taken into the mouth.
Digestion	Food is broken down into smaller particles including nutrients.
Absorption	Nutrients are absorbed into the blood.
Elimination	Undigested material is eliminated from the body.

The digestive system

The digestive system is an organ system in animals that functions to break down food to release nutrients that are absorbed into the body. The digestive systems of animals vary widely in structure and composition.

Example 3.09

Cnidaria is a phylum of invertebrate animals found exclusively in aquatic environments and includes corals, jellyfish and hydrazoa. Figure 3.27 shows the digestive system of a jellyfish.

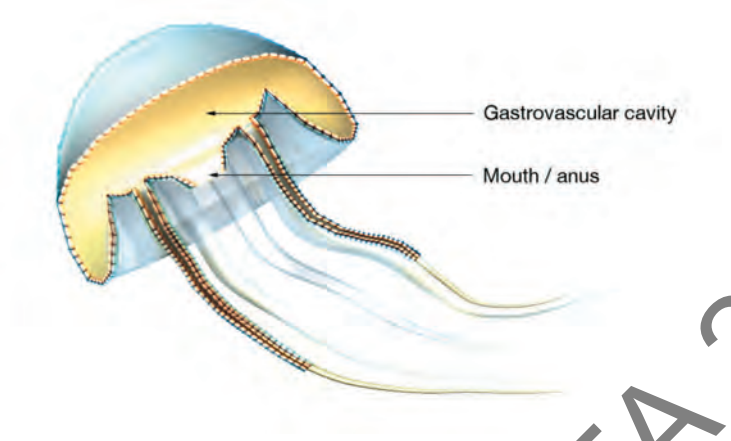


Figure 3.27: Digestive system (jellyfish).

Food enters the mouth and is stored in the gastrovascular cavity. Digestive enzymes are then secreted by cells lining the gastrovascular cavity which breaks down the food into smaller nutrients that are absorbed into the body. Waste products produced by the digestion and metabolism of food are excreted through the mouth which is equivalent to the anus in more complex animals.

Example 3.10

Arthropods are a phylum of invertebrate animals which includes insects, arachnids, and crustaceans. Figure 3.28 shows the digestive system of an insect.

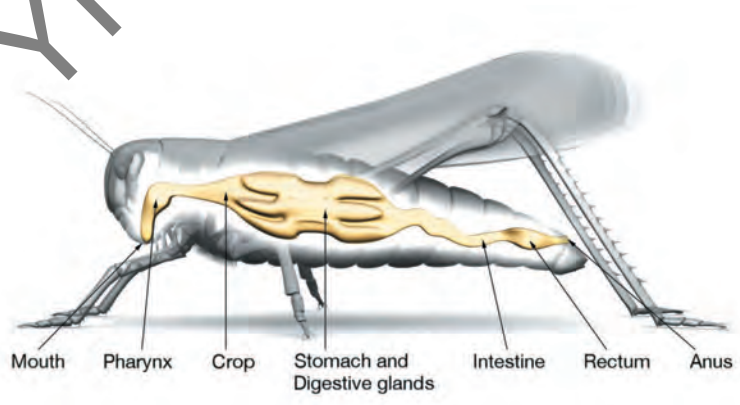


Figure 3.28: Digestive system (insect).

Food enters through the mouth and is temporarily stored in the crop where salivary enzymes begin the process of digestion. The partially digested food enters the stomach where digestive glands secrete enzymes that break down larger food particles into smaller nutrients that are absorbed into the circulatory system through the walls of the stomach and intestines.

Example 3.11

Vertebrate animals have a more complex digestive system consisting of many well-defined organs that carry out the process of digestion. Figure 3.29 shows the digestive system of a turtle.

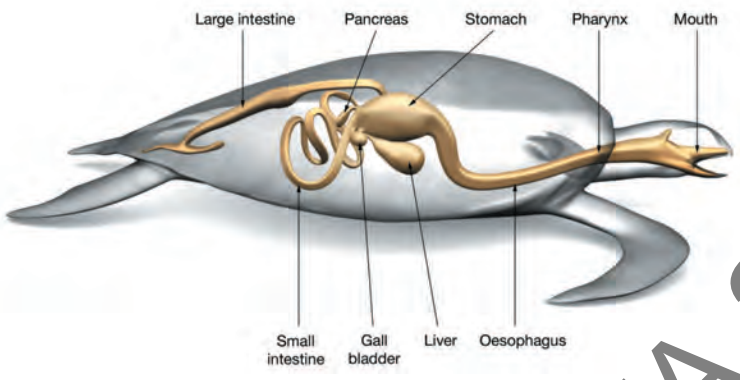


Figure 3.29: Digestive system (turtle).

Food enters the mouth and moves down the oesophagus to the stomach where it is broken down by digestive enzymes and stomach acid. The pancreas and liver secrete chemical compounds including bile and digestive enzymes that break down macromolecules into smaller nutrients for absorption into the blood through the small intestine.

Example 3.12

Ruminants are mammals that extract nutrients from plants by fermenting the ingested material in a four-chambered stomach before digestion. Figure 3.30 shows the digestive system of a cow.

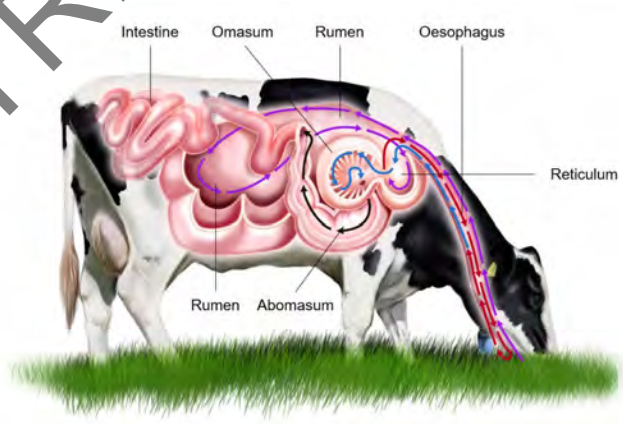


Figure 3.30: Digestive system (cow).

Food is moved into the **rumen** where it is exposed to bacteria that break down cellulose in the plant material. Food can be regurgitated from the **reticulum** to the mouth where it is chewed further to increase its surface area for digestion. Food passes into **omasum** where it is broken down mechanically before being moved to the **abomasum**, where the digestive enzyme lysozyme breaks down the bacteria and releases nutrients that are absorbed into the blood from the small intestine.

Human digestive system

The human digestive system consists of a series of organs that carry out the process of digestion and absorption of nutrients. Figure 3.31 shows the organs of the human digestive system.

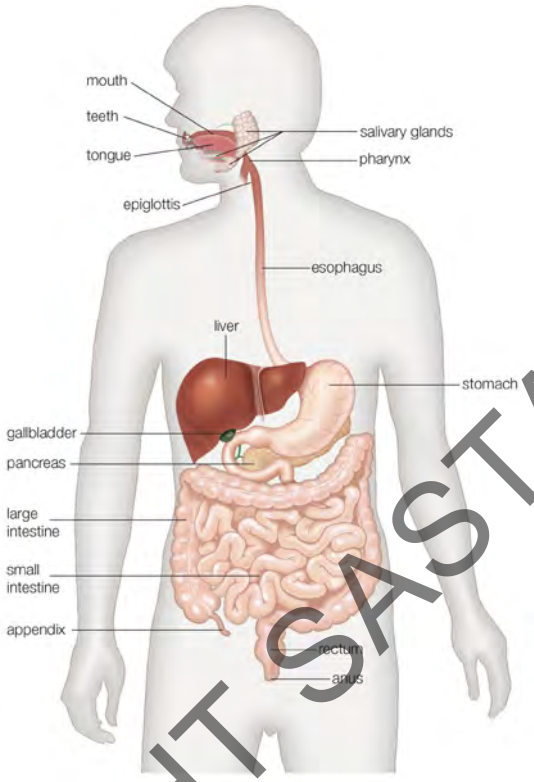


Figure 3.31: Digestive system (human).

Mouth

The process of digestion begins in the mouth where food is broken down by the physical actions of the teeth and tongue and the chemical action of **saliva**. The teeth and tongue break down food into smaller particles which are broken down further by digestive enzymes in saliva. Saliva is secreted by **salivary glands** positioned around the mouth (Figure 3.32).

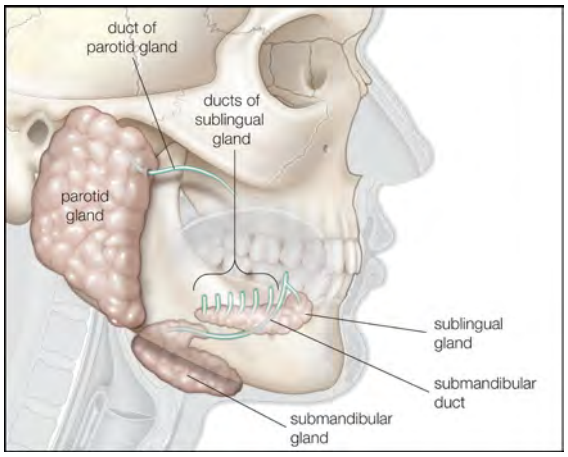


Figure 3.32: Location of the human salivary glands.

Each villus is lined with a thin layer of epithelial cells called **enterocytes** (Figure 3.38) that absorb nutrients from food passing through the small intestine. Enterocytes have a specialised cell membrane called a **brush border** containing as many as a thousand tiny projections called **microvilli** that increase the surface area to volume ratio for the absorption of nutrients into the blood.

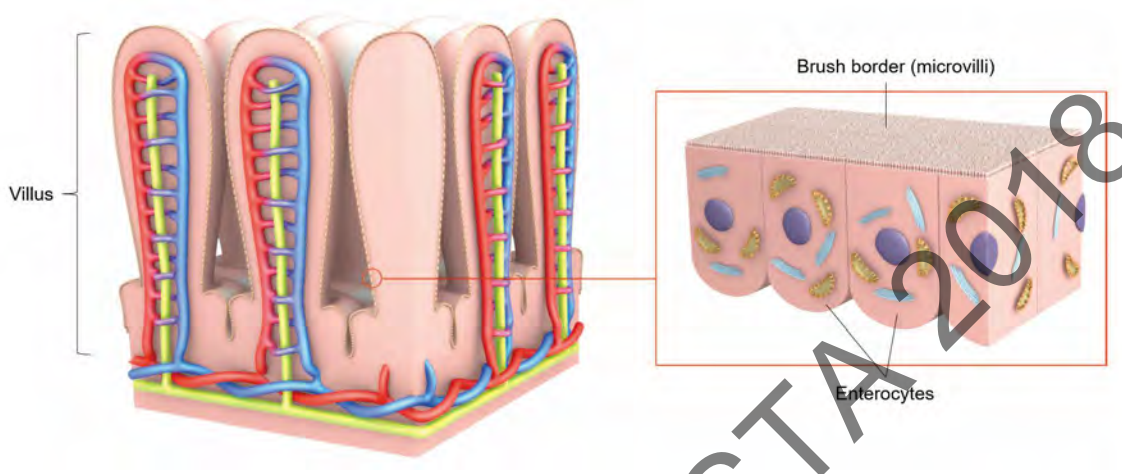


Figure 3.38: Enterocyte brush border.

Digestive enzymes

Digestive enzymes are protein molecules that break down macromolecules including proteins, polysaccharides and lipids into smaller nutrients that are absorbed into the blood through the enterocyte brush border. Many of the digestive enzymes are produced and secreted by the pancreas and enter the small intestine via the pancreatic duct. The main pancreatic enzymes secreted into the small intestine are identified in the table below.

Digestive enzyme	Substrate	Product(s)
Peptidase	Proteins	Amino acids
Lipase	Lipids	Fatty acids, glycerol
Amylase	Starch	Glucose

In addition to pancreatic enzymes, the enterocyte brush border contains many digestive enzymes that break down proteins and carbohydrates into amino acids and simple sugars that are absorbed into the blood. The most common digestive enzymes are identified in the table below.

Digestive enzyme	Substrate	Product(s)
Peptidase	Proteins	Amino acids
Lactase	Lactose	Glucose and galactose
Maltase	Maltose	Glucose
Sucrase	Sucrose	Glucose and fructose

Nutrient absorption

The brush border of villi in the small intestine acts as a nutrient exchange surface in humans and other animals. Nutrients are absorbed into enterocytes by simple diffusion, facilitated diffusion and active transport where they diffuse into blood capillaries as shown in Figure 3.39.

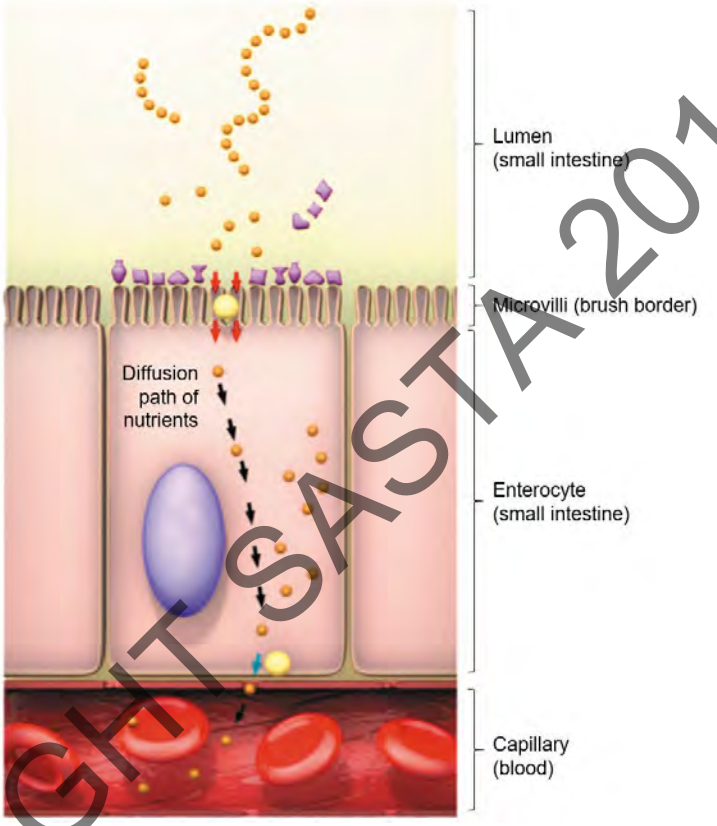


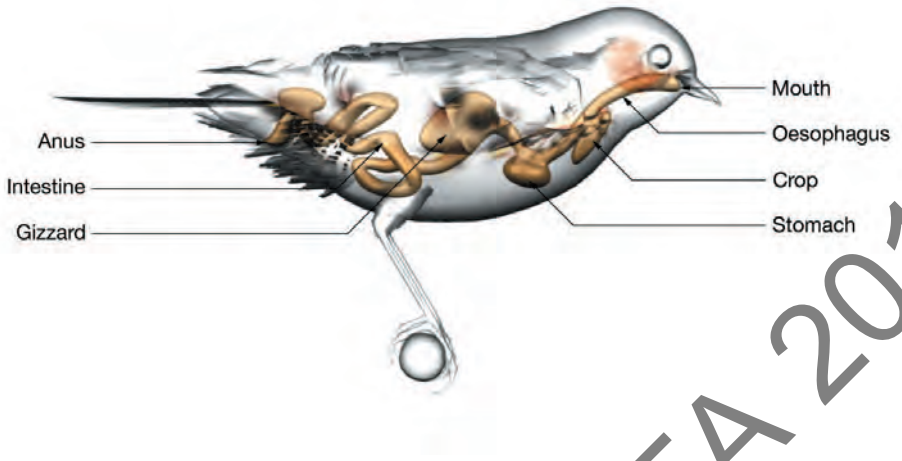
Figure 3.39: Nutrient exchange surface in animals.

The nutrient exchange surface has several properties that increase the rate at which nutrients are transported into the blood.

Property	Description
Microvilli brush border	The brush border increases the surface area to volume ratio for the absorption of nutrients into enterocytes.
Short diffusion path	The diffusion path between the lumen of the intestines and blood capillaries is very short.
Constant blood flow	The constant flow of blood maintains the concentration gradients of nutrients diffusing into the capillaries.
Presence of water	The lumen of the intestines is filled with water which enables the rapid diffusion of hydrophilic substances into enterocytes.

Question 66

The diagram below shows the digestive system of a small bird (avian).



(a) Identify two components of the avian digestive system that are not present in humans.

_____ (2 marks) **KA1**

(b) Birds do not have teeth, but they do secrete saliva onto food.

State two functions of saliva in digestion.

_____

_____ (2 marks) **KA2**

(c) The function of the crop is to store food temporarily before it is moved into the stomach.

State one advantage to birds of having a crop.

_____

_____

_____ (1 mark) **KA2**

(d) The gizzard contains muscles that mix and grind food into smaller particles.

(1) Name the organ that performs the same function in humans.

_____ (1 mark) **KA2**

(2) Birds may ingest small stones that are stored in the gizzard.

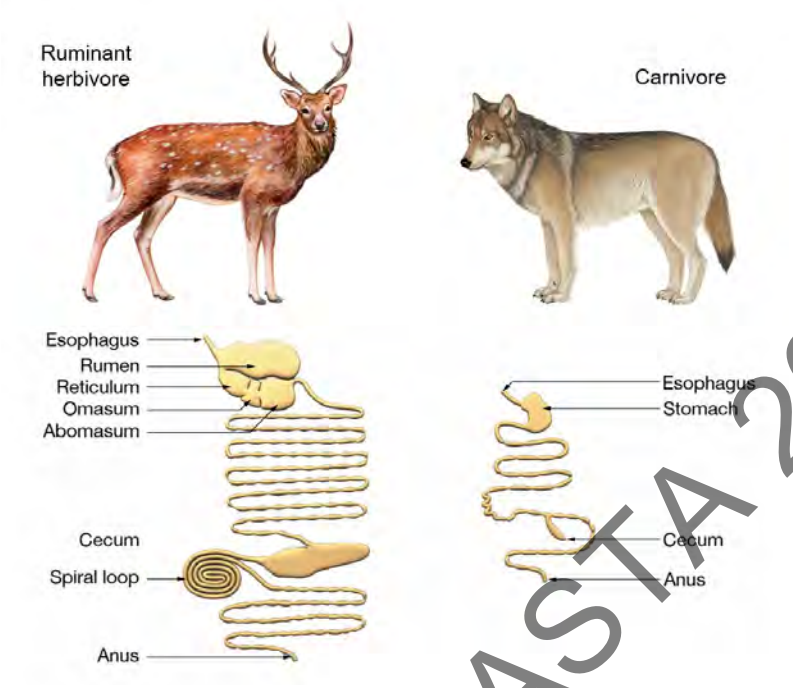
Suggest a function of these stones.

_____

_____ (1 mark) **KA2**

Question 67

The diagram below shows the digestive systems of two mammals.



(a) State the function of the oesophagus in the digestive system of mammals.

_____

_____ (1 mark) **KA1**

(b) Ruminant herbivores have a four-chambered stomach consisting of the rumen, reticulum, omasum, and abomasum.

(1) State the primary function of bacteria in the rumen.

_____ (1 mark) **KA1**

(2) State why food is regularly regurgitated back into the mouth from the reticulum of the stomach of a ruminant herbivore.

_____

_____ (1 mark) **KA1**

(c) Explain why herbivores have longer intestines than carnivores.

_____

_____

_____

_____ (2 marks) **KA1**

Nephrons

The cortex and medulla of the kidneys contain many tiny excretory tubules called **nephrons** that produce urine in the process of removing waste materials and excess substances from the blood. The human kidneys each contain approximately one million nephrons. Figure 3.45 shows the structure and features of a mammalian nephron.

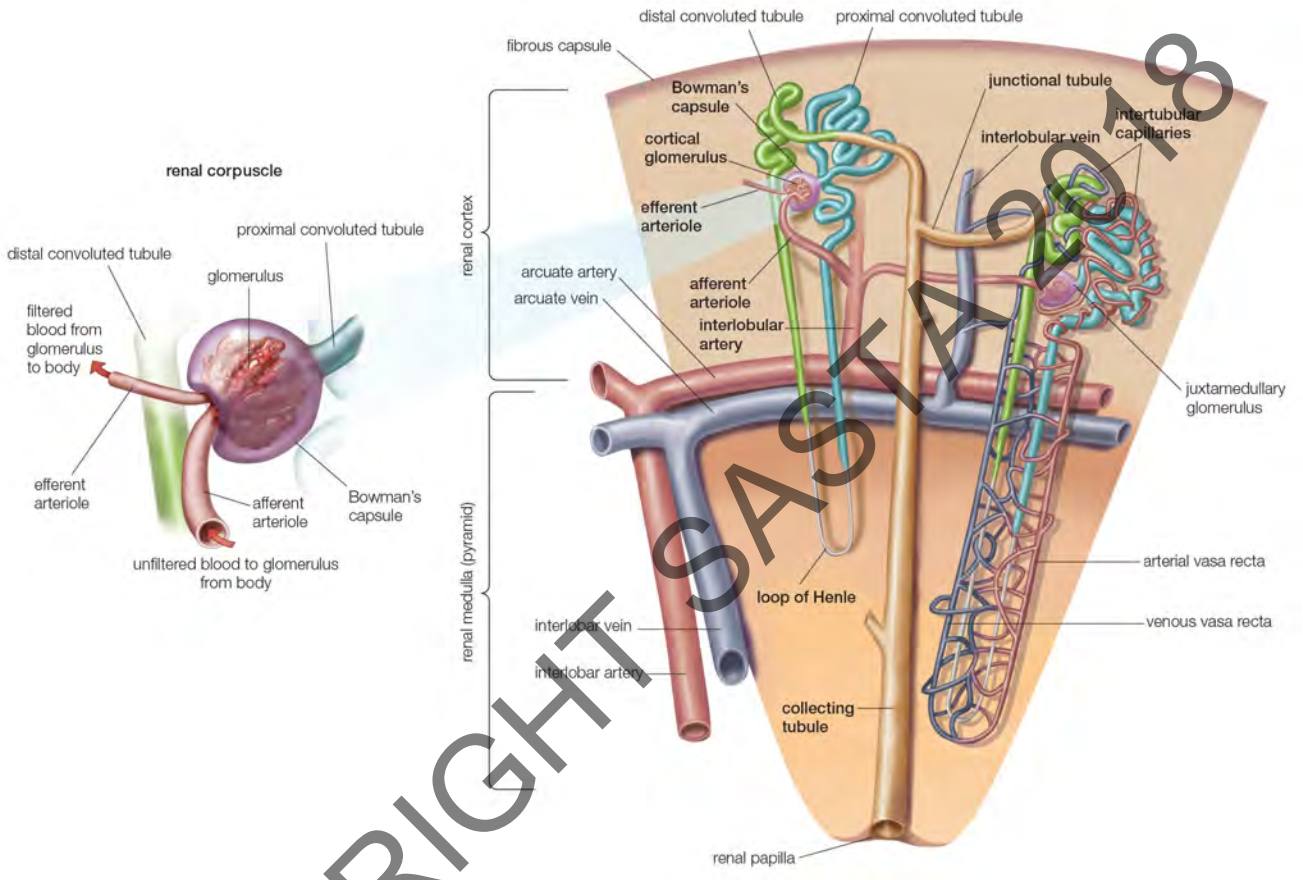


Figure 3.45: Structure and features of a mammalian nephron.

Each nephron is a long tubule measuring between 3 and 5 cm in length. At one end of the tubule is cup-like structure called **Bowman's capsule** that encloses a cluster of blood capillaries called the **glomerulus** (Figure 3.46).

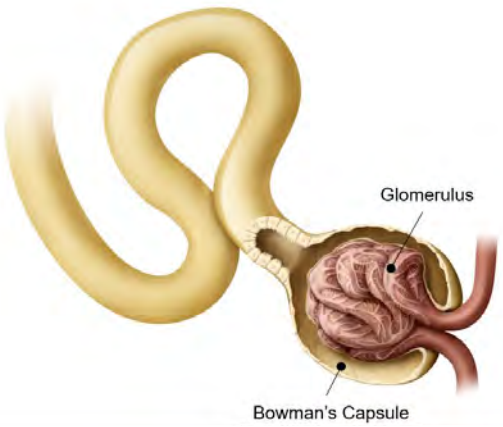


Figure 3.46: Glomerulus and Bowman's capsule

Selective reabsorption

Selective reabsorption is the process by which certain materials in the filtrate are reabsorbed into the blood from the proximal tubule. The process is called selective reabsorption as only selected materials are reabsorbed into the body where they are used to perform important functions.

Material reabsorbed	Function
Amino acids	Protein synthesis
Glucose	Respiration
Sodium ions	Metabolism
Water	Metabolism

The epithelial tissue lining the proximal tubule is an exchange surface for the selective reabsorption of materials into the blood. The epithelial tissue has a thickness of one cell, and each epithelial cell contains microvilli, forming a brush-border that increases the surface area to volume ratio for the selective reabsorption of materials (Figure 3.49).

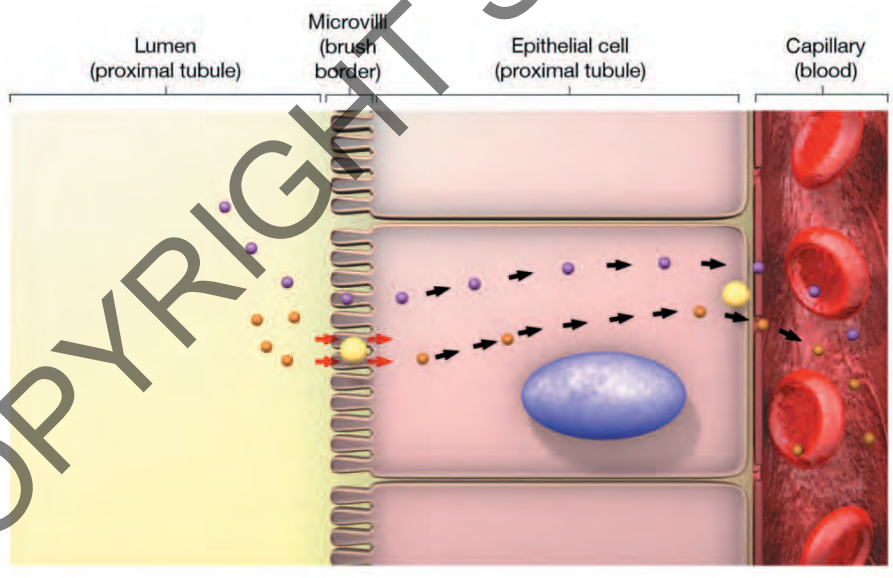


Figure 3.49: Selective reabsorption of materials.

Materials that are not selectively reabsorbed from the filtrate form **urine** which moves out of the nephron via the **collecting duct**. The collecting ducts drain into the ureters which transport urine to the bladder where it is stored before being excreted. Urine is primarily composed of nitrogenous wastes including urea and creatinine (in humans), water, and small amounts sodium, chloride, and potassium. The yellow colour of urine is due to the presence of **urobilin** which is a waste material derived from the decomposition of haemoglobin from red blood cells.

Single and double circulatory systems

There are two types of closed circulatory systems in vertebrate animals. Fish have a **single circulation system,** and amphibians, reptiles, birds and mammals have a **double circulation system.** In a single circulatory system, blood passes through the heart only once as it is pumped through gill capillaries and systemic capillaries in organs and tissues (Figure 3.60).

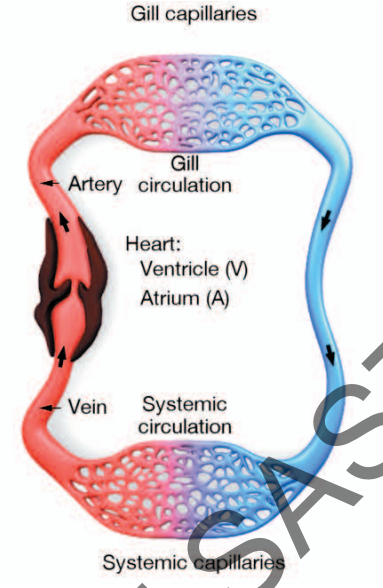


Figure 3.60: Single circulation system in fish.

In a double circulatory system, blood passes through the heart twice as it is pumped through two separate circuits called the **pulmonary** and **systemic circuits**. Deoxygenated blood is pumped into the pulmonary capillaries to be oxygenated in the pulmonary circuit, and oxygenated blood is pumped to the systemic capillaries in organs and tissues in the systemic circuit (Figure 3.61).

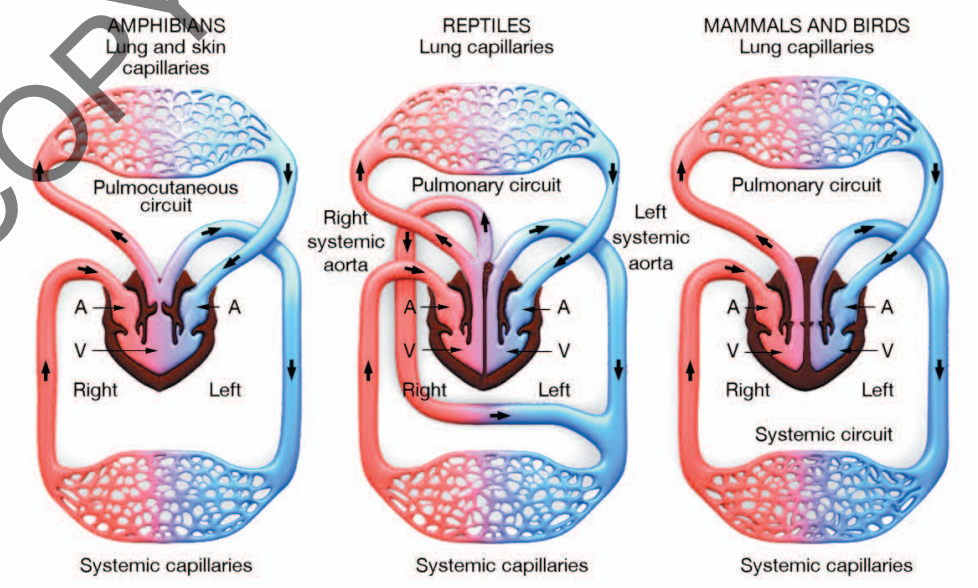


Figure 3.61: Double circulation systems in amphibians, reptiles, mammals and birds.

Blood

Blood is a component of connective tissue in animals that transports nutrients and oxygen to tissue cells for respiration, metabolism and growth as well as transporting waste products to the excretory organs. The composition of blood varies between invertebrates and vertebrates, but most blood types contain **plasma** which is a mixture of water, proteins, salts, sugars and waste materials, as well as different cell types including red and white blood cells. The composition of human blood is illustrated in Figure 3.62.

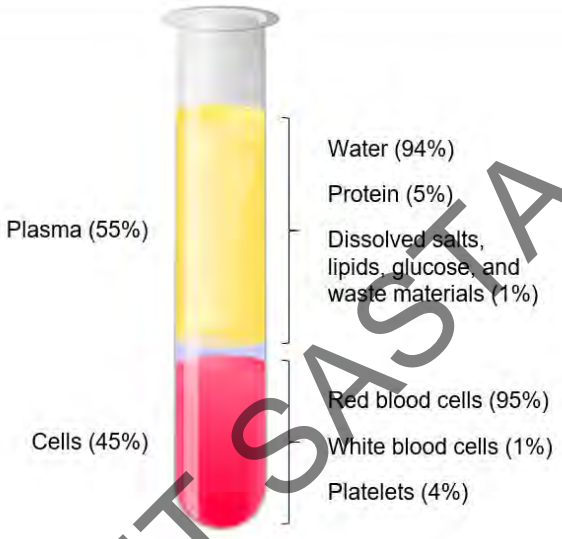


Figure 3.62: Composition of human blood.

The red blood cells of vertebrates contain a protein called **haemoglobin** (Figure 3.63). The primary function of haemoglobin is to transport oxygen to body cells for aerobic respiration. A single red blood cell contains over 250 million molecules of haemoglobin and each molecule stores four oxygen molecules allowing vertebrates to transport a large amount of oxygen to body cells.

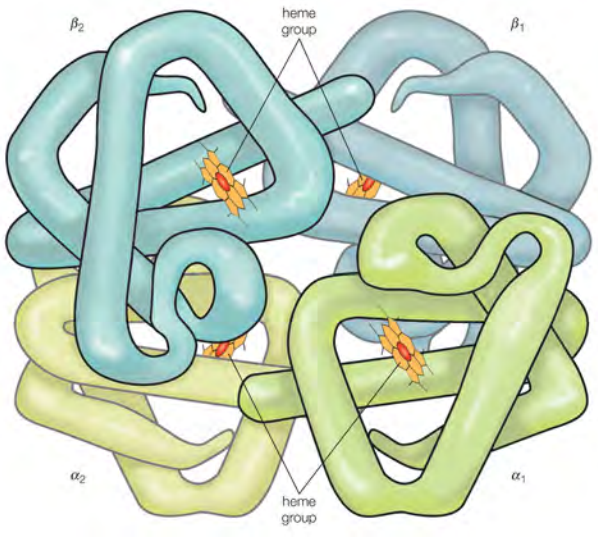


Figure 3.63: Haemoglobin molecule.

Blood Vessels

Blood vessels are organs that transport blood around the circulatory system. There are three types of blood vessels in vertebrates called **arteries**, **veins**, and **capillaries** and each has a unique structure and function in the circulatory system (Figure 3.64).

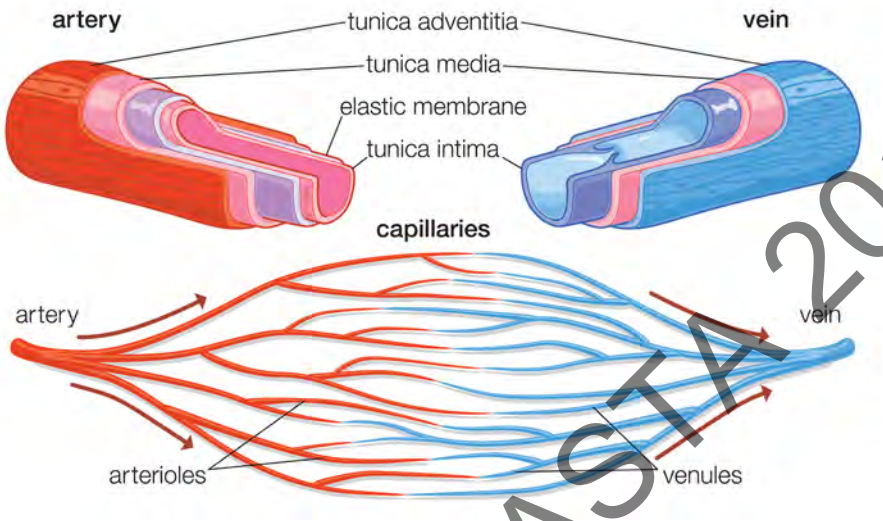


Figure 3.64: Three types of blood vessels in vertebrate animals.

The primary function of the three types of blood vessels in vertebrates is identified below.

Blood vessel	Primary function
Artery	Transports blood from the heart to the organs.
Vein	Transports blood from the organs to the heart.
Capillary	Exchanges nutrients, respiratory gases and waste materials with body cells and extracellular fluids.

The tissue composition varies between the three blood vessels as shown in the table below.

Tissue	Artery	Vein	Capillary
Muscle	Thick	Thin	None
Connective (elastic)	Thick	Thin	None
Epithelial	Thin	Thin	Thin

The table shows that all blood vessels have a thin layer of epithelial tissue called **endothelium.** Endothelial cells produce substances that promote smooth blood flow through a vessel. The muscle and connective tissues are thicker in arteries as these vessels transport blood under higher pressure from the heart to the organs and tissues. Muscle and connective tissues are absent in capillaries as these vessels must be thin to reduce the diffusion path for the exchange of materials with body cells.

The Heart

The heart is an organ in some invertebrates and all vertebrate animals that pumps blood through the blood vessels of the circulatory system. The structure of the heart varies in animals, but each contains chambers, valves and blood vessels that work together to pump blood through the circulatory system. In birds and mammals, the heart is a four-chambered pump situated between the lungs and slightly to the left of centre (Figure 3.65).

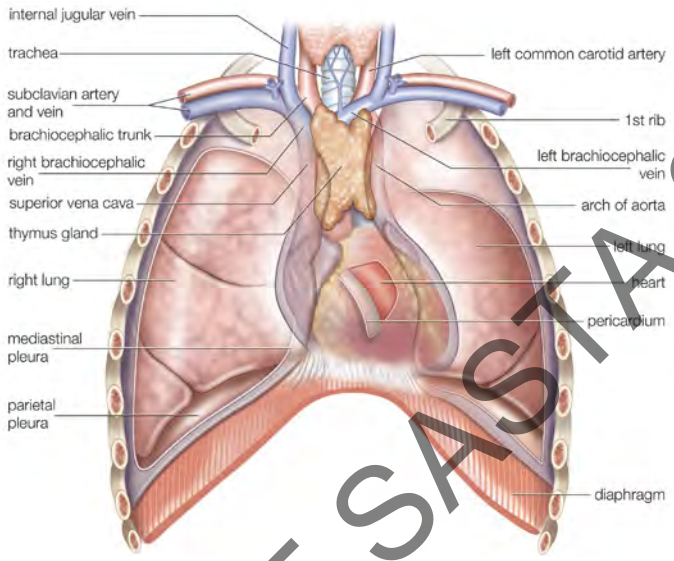


Figure 3.65: The position of the heart in birds and mammals.

The heart cavity in birds and mammals is divided into the right and a left heart, which is subdivided into two chambers as shown in Figure 3.66. The upper chamber is called an **atrium,** and the lower chamber is called a **ventricle**. The atria act as receiving chambers for blood entering the heart from the lungs and other organs, and the ventricles pump blood out of the heart to the organs. The atria and ventricles are separated by valves that allow blood to flow in one direction only.

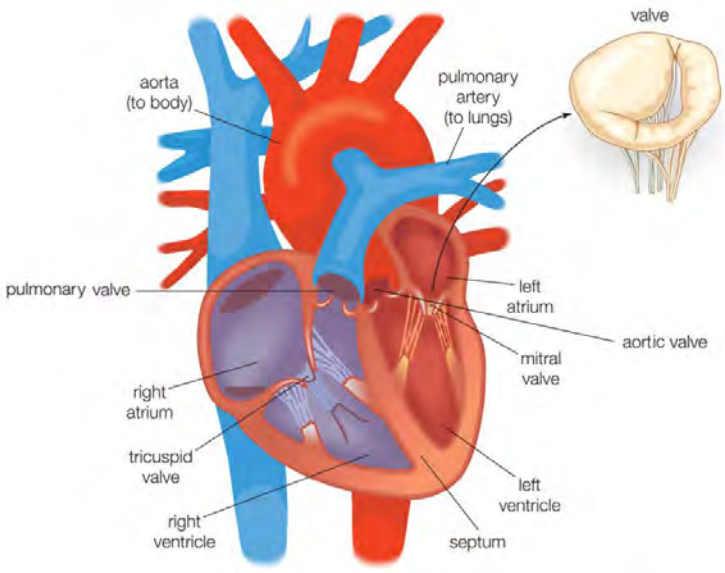


Figure 3.66: Atria and ventricles in the human heart.

The cardiac cycle

A single heartbeat involves the movement of blood between the different chambers of the heart. The pumping action of the heart is caused by alternating contractions and relaxations of the muscle tissue that are stimulated by electrical impulses from the **sinoatrial node** in the muscle of the right atrium, and the **atrioventricular node** located at the junction of the two atria (Figure 3.67).

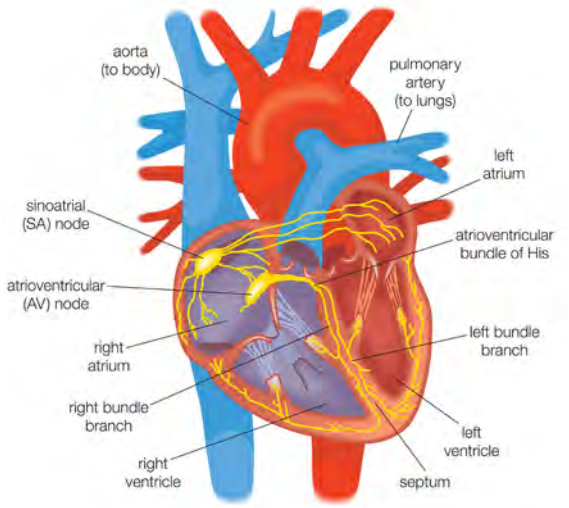


Figure 3.67: Conducting system of the heart.

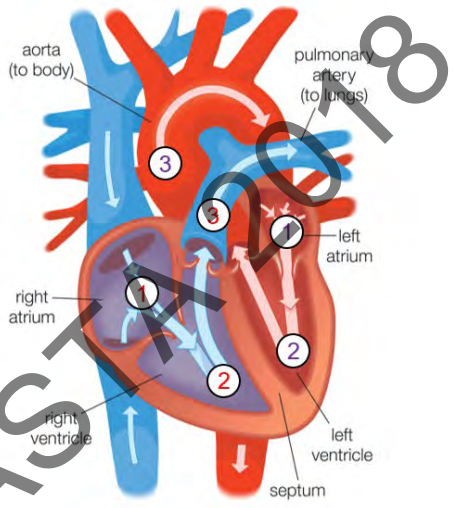


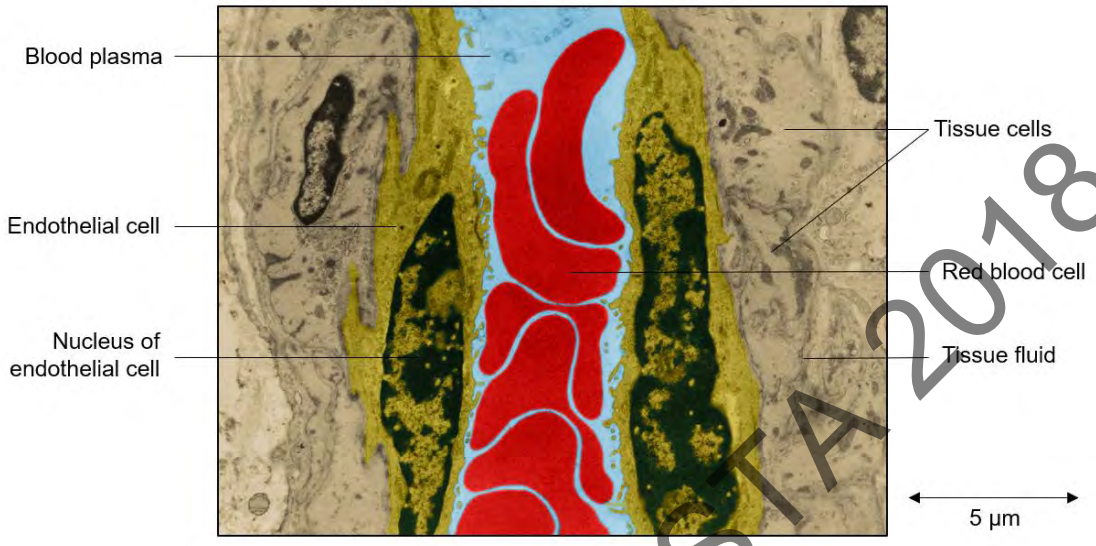
Figure 3.68: The cardiac cycle.

The sequence of events occurring in one heartbeat is called the **cardiac cycle.** The cardiac cycle consists of three stages that are described in the table below. Each of the three stages has been labelled in Figure 3.68.

Stage	Description
1. Diastole	The atria start to fill with blood. The right atrium receives deoxygenated blood from the body, and the left atrium receives oxygenated blood from the lungs.
2. Atrial systole	An impulse from the sinoatrial node causes the two atria to contract, forcing blood into the ventricles through the open mitral and tricuspid valves. The mitral and tricuspid valves then close to prevent blood from flowing back into the atria.
3. Ventricular systole	An impulse from the atrioventricular node causes the two ventricles to contract, forcing blood into the pulmonary artery and aorta through the open pulmonary and aortic valves. The pulmonary and aortic valves then close to prevent blood from flowing back into the ventricles.

Question 82

The diagram below is a coloured transmission electron micrograph (TEM) showing red blood cells flowing through a blood capillary.



(a) Materials are exchanged between blood and tissue fluid.

(1) State the primary function of tissue fluid.

_____

_____ (1 mark) **KA1**

(2) Identify and state the function of one material transported in blood that diffuses into tissue fluid.

_____

_____ (2 marks) **KA1**

(b) Describe and explain two structural features blood capillaries that increases the efficiency of exchange of materials between blood and tissue fluid.

_____

_____

_____

_____ (2 marks) **KA1**

(c) State two differences in blood composition at the arterial and venous ends of a capillary.

_____

_____ (2 marks) **KA1**

3.10: Transport in plants

In plants, transport of water and mineral nutrients from the roots occurs via xylem involving root pressure, transpiration, cohesion of water molecules, and osmosis.

- Explain how water moves in, through, and out of a plant.

Vascular tissue facilitates the transport of water, nutrients and organic compounds in plants. There are two types of vascular tissues in plant organs called **xylem** and **phloem**.

Xylem

Xylem is a type of vascular tissue that transports water and dissolved minerals from the roots to tissue cells in the body of a plant. Xylem is composed of specialised, water-conducting cells known as **tracheids** and **vessel elements**, both of which are hollow, narrow, elongated and are covered in **pits** that allow water and minerals to flow between adjacent cells (Figure 3.73).

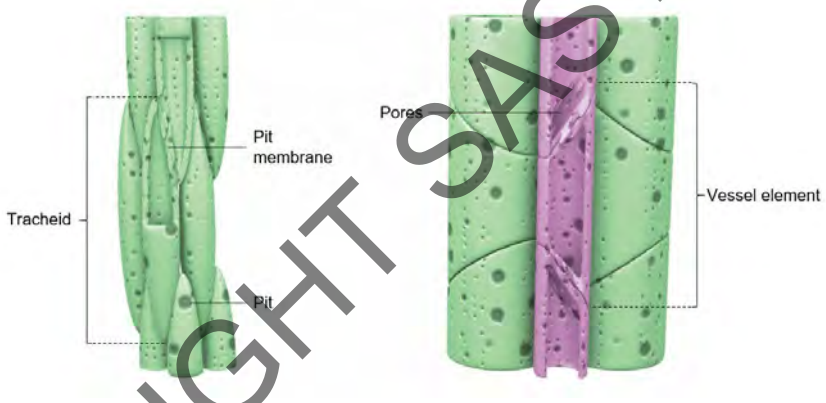


Figure 3.73: Tracheids and vessel elements of xylem.

Tracheids have a thin modified cell wall known as the **pit membrane** which permits the flow of water between cells while preventing the passage of damaging air bubbles. Vessel elements have **pores** that allow the unimpeded flow of water between cells. Xylem vessels are composed of vertical columns of tracheids and vessel elements that conduct water from roots to leaves (Figure 3.74).

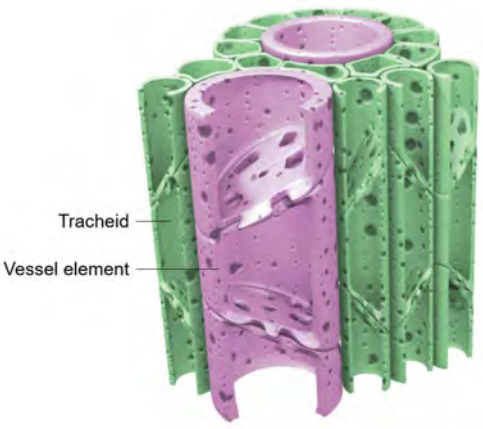


Figure 3.74: Xylem vessel.

Transport of water in plants

The transportation of water and dissolved nutrients in plants occurs in several stages and involves the absorption of water from soil, the diffusion of water into xylem vessels, the conduction of water through xylem, and the evaporation of water from the aerial parts of the plant (Figure 3.75).

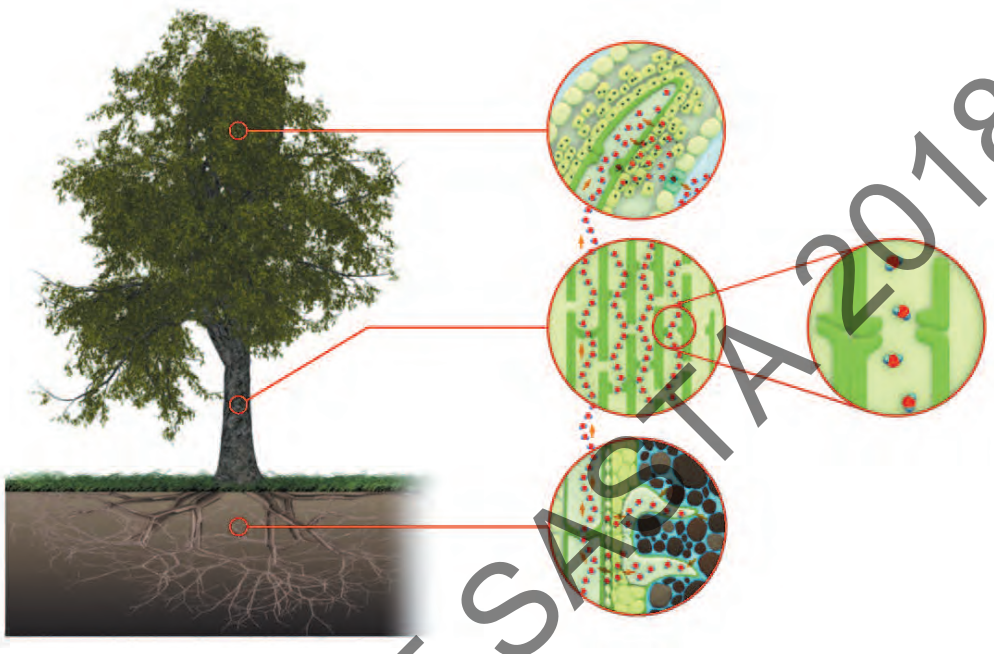


Figure 3.75: Transport of water in plants.

Water and dissolved nutrients are absorbed from the soil through root epidermal cells. The diffusion of water occurs by osmosis, and the diffusion of nutrients occurs by facilitated diffusion and active transport. Water and dissolved nutrients then diffuse from root epidermal cells to xylem vessels via **intracellular** or **extracellular** pathways. The intracellular pathways involve the movement of water through the cytoplasm of root cells whereas the extracellular pathway involves the movement of water through cell walls as shown in Figure 3.76.

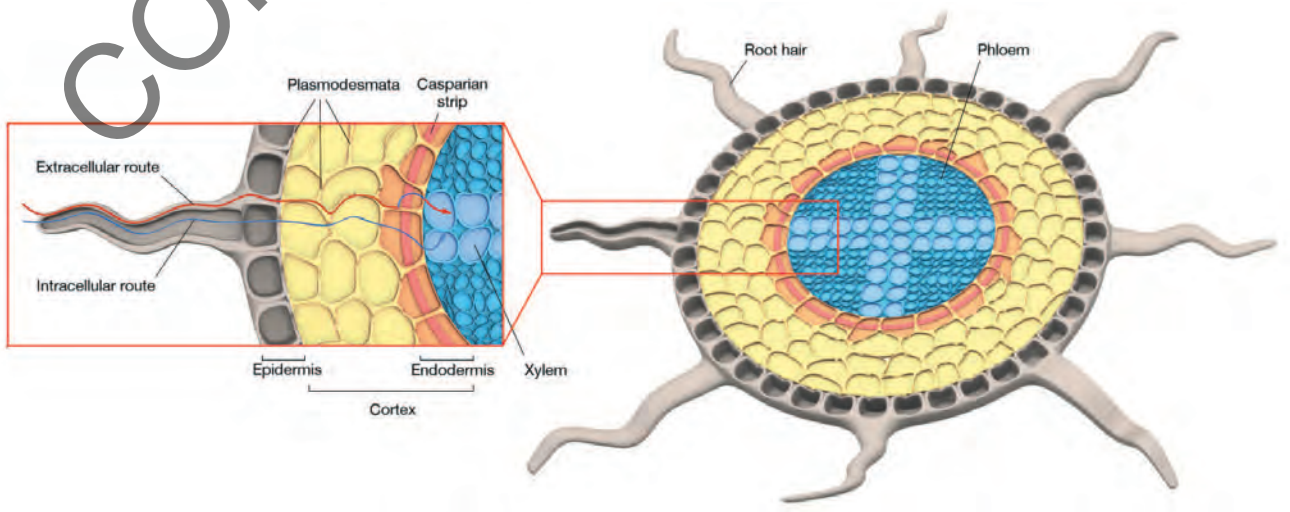


Figure 3.76: Transport of water in plants.

Xylem vessels typically contain a continuous column of water and dissolved nutrients called **xylem sap** that flows from roots to leaves. The upward movement of xylem sap is driven by forces including **root pressure**, **capillary action**, and **transpirational pull**.

Force	Description
Root pressure	The diffusion of water into root xylem vessels from soil creates pressure that forces xylem sap upwards from roots to leaves.
Capillary action	Xylem sap is forced upwards by a combination of cohesive forces between water molecules and adhesive forces between water molecules and the cell walls of xylem cells.
Transpirational pull	The evaporation of water into the atmosphere in transpiration creates a negative pressure at the top of a plant that pulls xylem sap upwards from roots to leaves.

The upward movement of xylem sap is dependent on the process of transpiration, and the resulting flow of water through the plant is called the **transpiration stream**. The transpiration stream has several functions in plants including the transportation of water to leaf cells for photosynthesis and the maintenance of turgor pressure, as well as the transportation of minerals to leaf cells for metabolism. The upward movement of the transpiration stream is summarised in Figure 3.77.

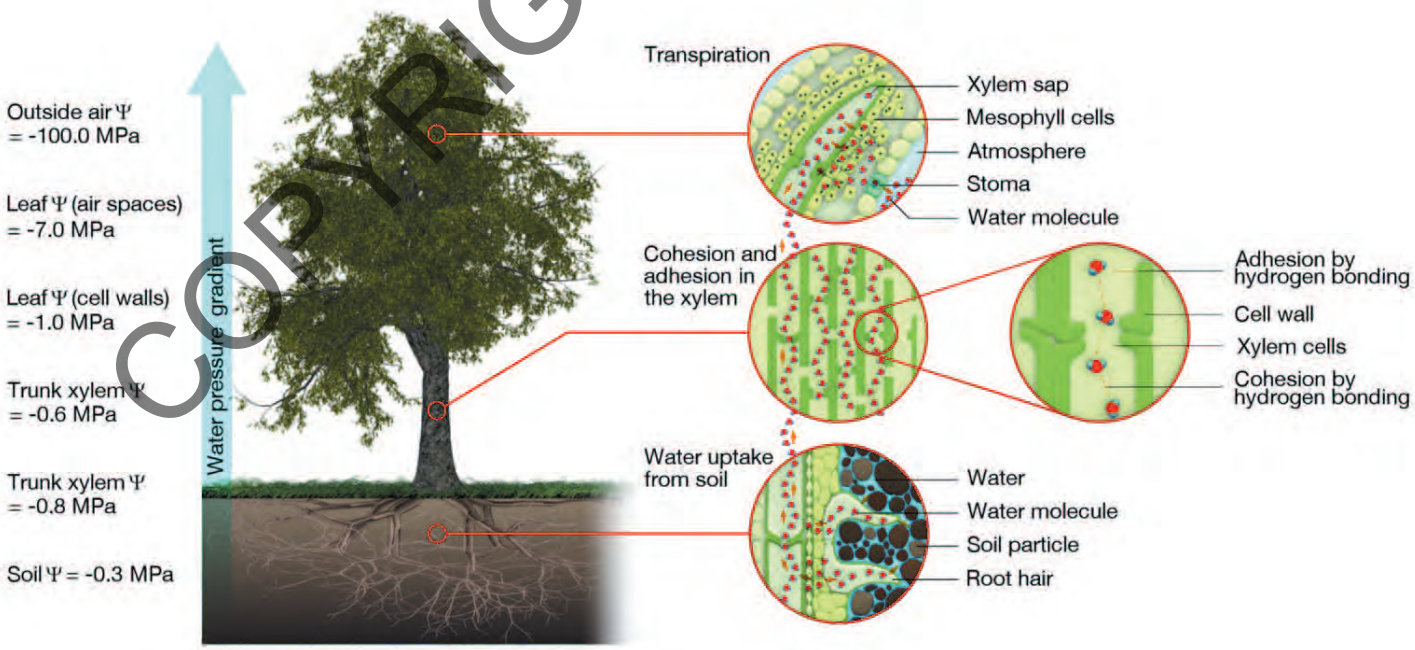


Figure 3.77: Transport of water in plants.

Transport of the products of photosynthesis and some mineral nutrients occurs by translocation in the phloem. They may be stored for later use.

- Describe the transport and storage of materials in plants.

The transport of sugars and other soluble organic compounds produced in photosynthesis is facilitated by a type of vascular tissue called **phloem**.

Phloem

The leaves of plants produce sugars and other soluble organic compounds in photosynthesis. The resulting material, called **phloem sap**, is transported from leaves to tissue cells in phloem. Phloem is composed of specialised conducting cells known as **sieve tube elements** that transport phloem sap and **companion cells** that carry out life processes that support sieve tube elements (Figure 3.78).

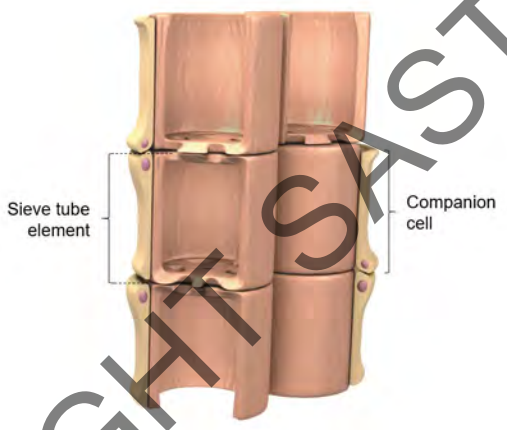


Figure 3.78: Sieve tube elements and companion cells in phloem.

Sieve tube elements have modified cell walls known as **sieve plates** which permit the unimpeded flow of phloem sap between adjacent cells. Mature sieve tube elements lack a nucleus and most organelles and are reliant on companion cells for metabolism. Phloem vessels are composed of vertical columns of sieve tube elements surrounded by various support cells (Figure 3.79).

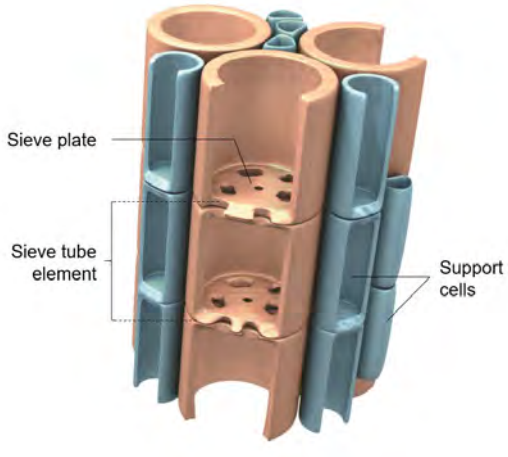


Figure 3.79: Xylem vessel.

Translocation

Photosynthesis occurs primarily in palisade and spongy mesophyll cells in plant leaves. The products of photosynthesis include glucose as well as other water-soluble organic compounds including glycerol and amino acids. These materials are transported in phloem sap from nutrient-rich cells called **source cells** to nutrient-deficient cells, called **sink cells**, in other tissues. Source cells are typically located in leaves, but tissue cells in stems and roots also function as source cells when leaves become nutrient-deficient. The materials present in phloem sap may be used by sink cells as raw materials for respiration, metabolism and growth, or they may be stored for later use. The transport of phloem sap between a source cell and a sink cell is called **translocation** (Figure 3.80).

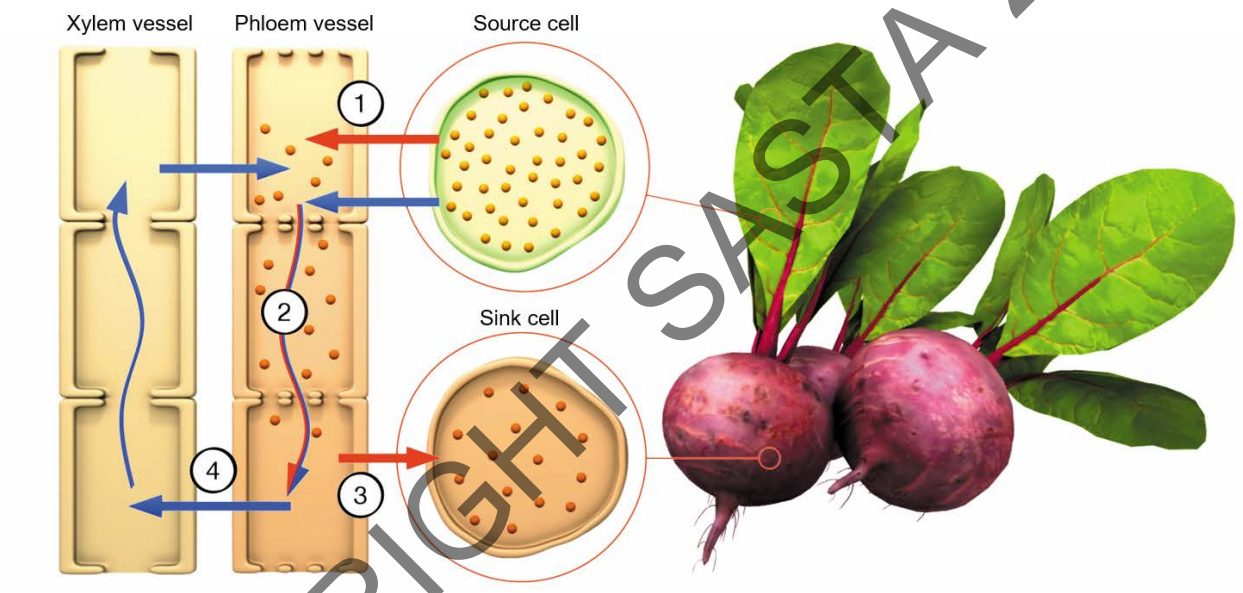
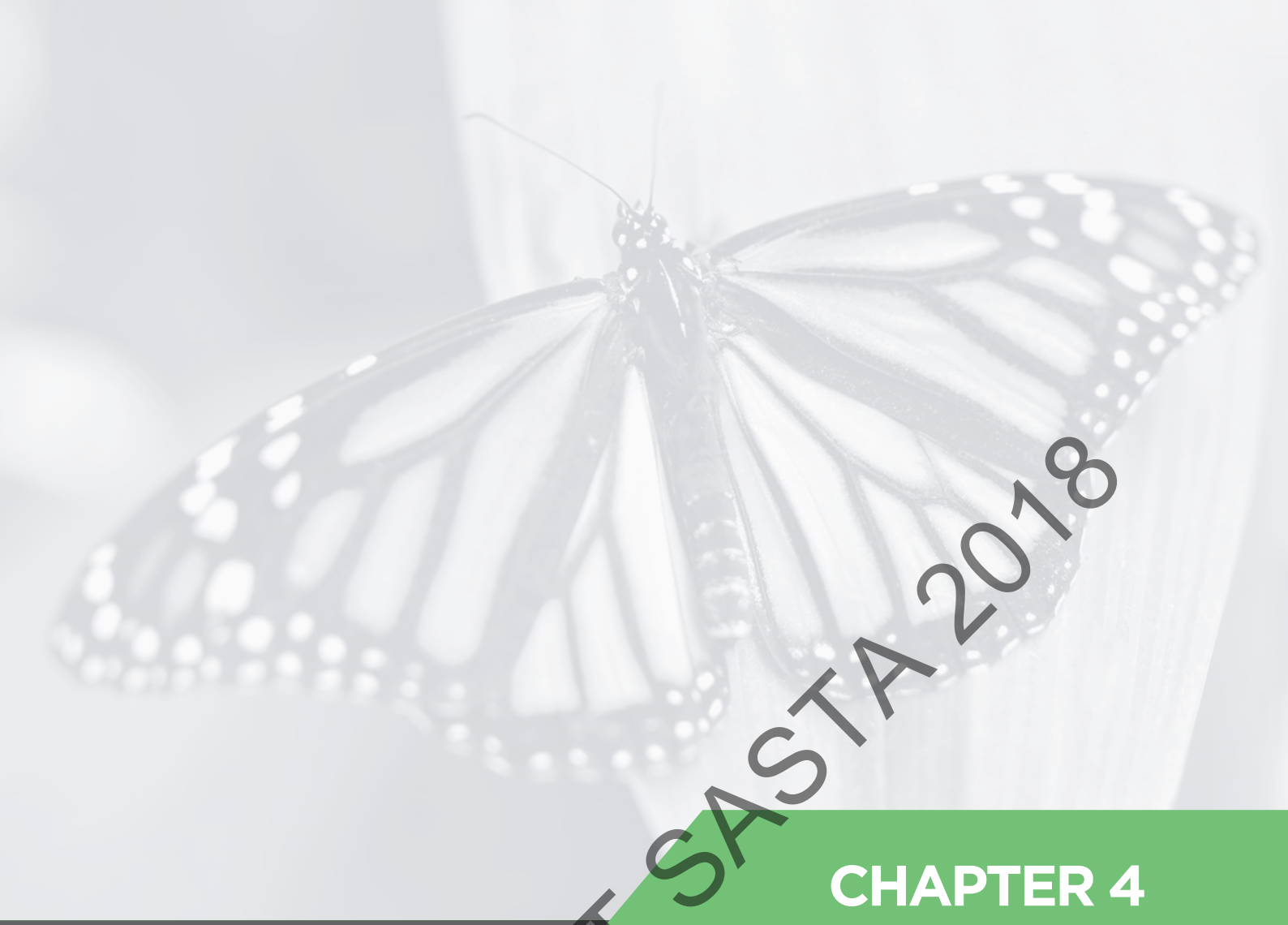


Figure 3.80: Translocation in plants.

The movement of phloem sap from source to sink cells in translocation is explained using the **pressure-flow hypothesis**.

1. Sugars and other materials produced by a source cell are actively transported into phloem vessels.
2. Water flows into phloem vessels by osmosis due to the increase in solute concentration caused by the diffusion of sugar.
3. The increased water pressure forces phloem sap through the phloem vessels towards sink cells.
4. Sugar and other materials are transported into sink cells from phloem vessels. Water diffuses back into xylem vessels and is transported back to source cells.



CHAPTER 4

TOPIC 4: BIODIVERSITY AND ECOSYSTEM DYNAMICS

4.1: Biodiversity

Biodiversity is the variety of all living things and includes diversity in genetics, species, and ecosystems.

In general, the higher the biodiversity of an ecosystem, the more stable it is.

- Distinguish between a species, population, community, and an ecosystem.
- Describe diversity in examples of species and ecosystems.

Ecology is the study of the relationships between living things and the environment including the interactions of living things with each other and with the nonliving components of the environment. Ecologists study the interactions between living things and the non-living environment at the level of species, populations, communities and ecosystems.

Species

The term **species** is used to define a group of related organisms that share common characteristics. In the context of plants and animals, the term species refers to a group of organisms that can produce fertile offspring through sexual reproduction.

Example 4.01

The emperor penguin (*Aptenodytes forsteri*) is a penguin species native to Antarctica (Figure 4.01). The emperor penguin is classified as a species as a sexually-mature male and female penguin can produce fertile offspring through sexual reproduction.

The king penguin (*Aptenodytes patagonicus*) is a penguin species native to the subantarctic and temperate islands near Antarctica (Figure 4.02). King penguins are classified as a separate species to emperor penguins as members of the different species are incapable of producing fertile offspring through sexual reproduction. This concept will be explored further in Topic 4.2.

Figure 4.01: Emperor penguins

Figure 4.02: King penguins

Population

The term **population** refers to a group of living things of the same species inhabiting a common location at the same time.

Example 4.02

The brown fur seal (*Arctocephalus pusillus*) is a species of seal native to Southern Africa and Southern Australia. Figure 4.03 shows a population of brown fur seal in the Cape Cross Seal Reserve in western Namibia, Africa. The group is defined as a population as there are many members of the same species (*Arctocephalus pusillus*) living together in the same location at the same time.

Figure 4.03: Population of brown fur seal in western Namibia, Africa.

Community

The term **community** refers to an assembly of interacting populations of various species inhabiting a common location at the same time. Figure 4.04 shows a community of insects, birds, and small mammals living in a tree.

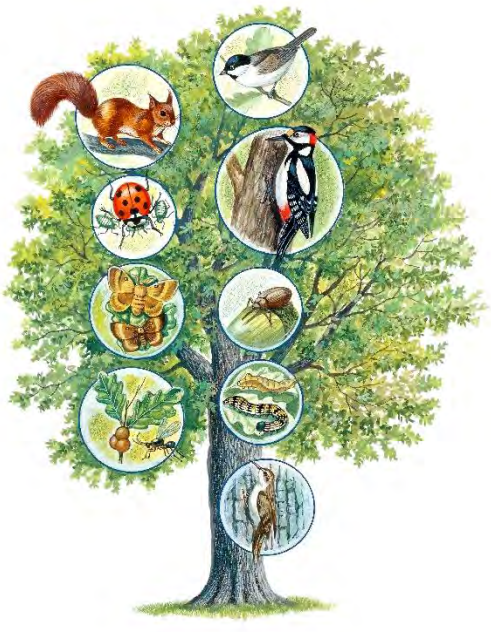


Figure 4.04: Biological community living in a tree.

Importance of biodiversity

Biodiversity is important to humans for numerous reasons that are outlined in the table below.

Reason	Description
Cultural	Many cultures have a close association with biodiversity. Indigenous Australians have strong connections to biodiversity arising from spiritual beliefs about living things.
Economic	Biodiversity provides humans with raw materials to produce consumer products including clothing, cosmetics, food, fuels, medicines, timber and paper.
Environmental	Biodiversity provides stable and functioning ecosystems that produce oxygen and clean water, as well as removing carbon dioxide and other pollutants from the atmosphere.
Recreational	Many recreational pursuits including camping, fishing, and hiking rely on the unique biodiversity of an ecosystem. Biodiversity is also a factor that influences tourism.
Scientific	Biodiversity provides a large body of data for scientists to study the natural world and provide supportive strategies for the conservation of ecosystems.

Global biodiversity is under constant threat from human activity including air and water pollution, warfare, urban expansion, farming and agriculture, logging, mining, and drilling. These factors all contribute to a loss of species diversity which in turn, causes corresponding losses in both genetic and ecosystem diversity. Figure 4.14 shows several regions with high biodiversity that are under increasing threat from human activity.

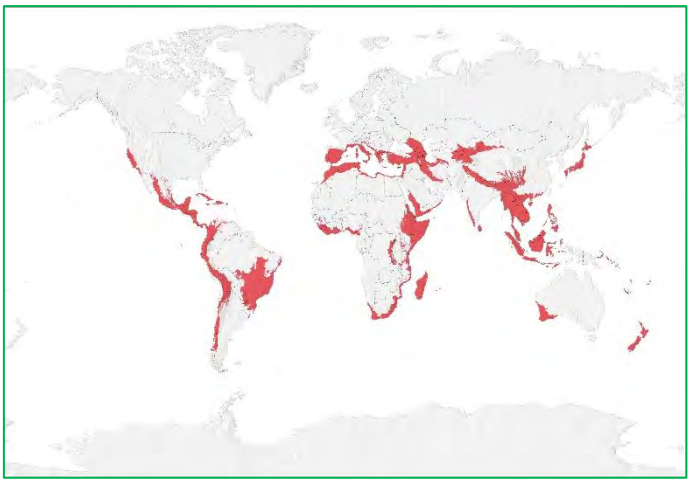


Figure 4.14: Biodiversity hot-spots that are under threat of human activity.

The human impacts on ecosystems will be explored further in Topic 4.8.

4.2: Classification

Biological classification is hierarchical and indicates the relationship between organisms based on their physical structures and the similarities in shared molecular sequences.

There is an internationally agreed system of nomenclature of species which undergoes revision.

- Distinguish between scientific names and common names for species.
- Recognise that very closely related species have similar scientific names.
- Discuss the advantages of an internationally agreed system of nomenclature.

Classification is a hierarchical system of categories based on the natural relationships between living things including similarities in genes and physical features. One of the simplest methods of classifying living things is called **artificial classification**.

Artificial classification

Artificial classification is a method of classifying living things according to easily observable and describable characteristics.

Example 4.10

Figure 4.15 shows nine animal species.

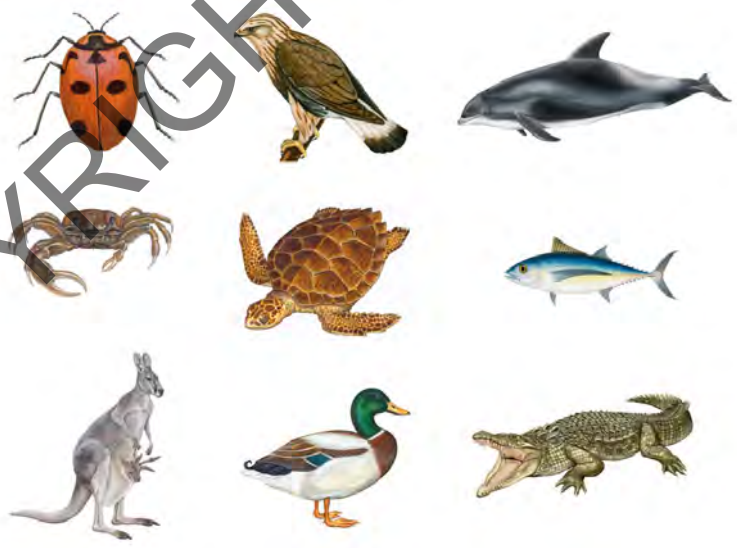


Figure 4.15: Animal species.

Artificial classification is used to group the animals based on similar observable characteristics.

- The dolphin, turtle, fish, crocodile, crab, and duck are **aquatic** organisms.
- The ladybug, hawk, and duck are capable of **winged flight**.
- The ladybug and crab have an **exoskeleton**.
- The hawk, ladybug, crab, turtle, crocodile, and duck **lay fertilised eggs**.

Dichotomous key

Artificial classification is the basis for the creation of a **classification key**. A classification key is a series of questions about the physical characteristics of a living thing. The answers to the questions are used to identify an organism or place that organism into a group. A **dichotomous key** is a method of identifying living things based on a series of contrasting statements about the physical or biological characteristics of the organisms.

Example 4.11

Figure 4.16 shows six invertebrate animals that have similar physical characteristics including an exoskeleton (external skeleton), a segmented body, and pairs of jointed appendages.

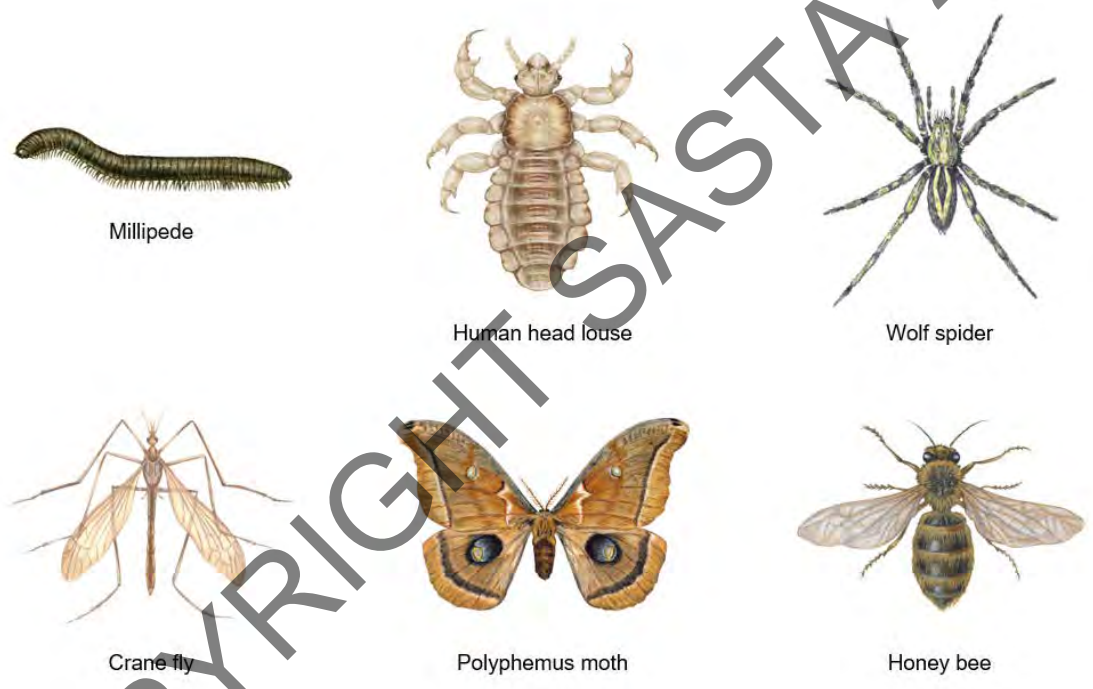


Figure 4.16: Invertebrate animal species.

The first step in developing a dichotomous key is to list the physical characteristics of each living thing. This is done through physical examination of each organism as well as conducting research using credible sources including books and encyclopedias.

The second step is to identify characteristics that may be used to differentiate between the living things such as the number of pairs of legs, the presence or absence of wings, the number of pairs of wings, and the length of the antennae relative to the body length of the organism.

Millipede	Head louse	Wolf spider	Crane fly	Moth	Honey bee
Many legs	3 pairs of legs	4 pairs of legs	3 pairs of legs	3 pairs of legs	3 pairs of legs
No wings	No wings	No wings	Wings	Wings	Wings
Short antennae	Short antennae	No antennae	Short antennae	Long antennae	Short antennae

Question 95

The diagram below shows six animals.

(a) Artificial classification is used to classify living things.

State the method by which organisms are grouped using artificial classification.

_____

_____ (1 mark) **KA1**

(b) Construct a simple dichotomous key to identify the six animals.

(6 marks) **KA1**

Taxon

A **taxon** (plural taxa) is a unit of biological classification. Living things are grouped into taxa based on shared characteristics. All species grouped into a taxon have evolved from a common ancestor. The eight recognised taxa are arranged in a hierarchal order from most inclusive to least inclusive: Domain, Kingdom, Phylum, Class, Order, Family, Genus, and Species (Figure 4.20).

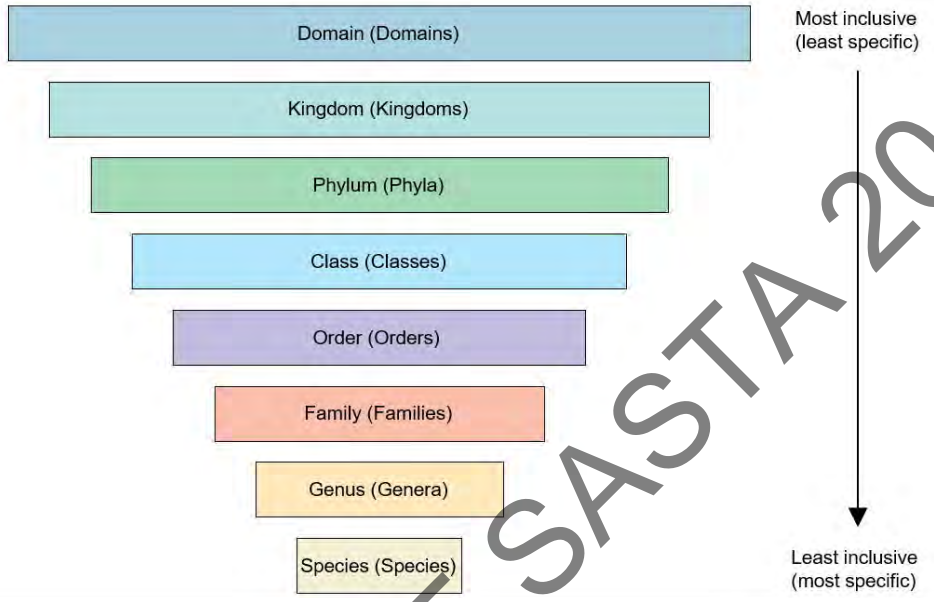


Figure 4.20: Taxonomic hierarchy.

Living things belong to one of three domains: Archaea, Bacteria and Eukaryota. The domain is the least specific of the taxa and classifies organisms as prokaryotes (Archaea and bacteria) or eukaryotes (Eukaryota). Figure 4.21 shows several living things that belong to each domain.

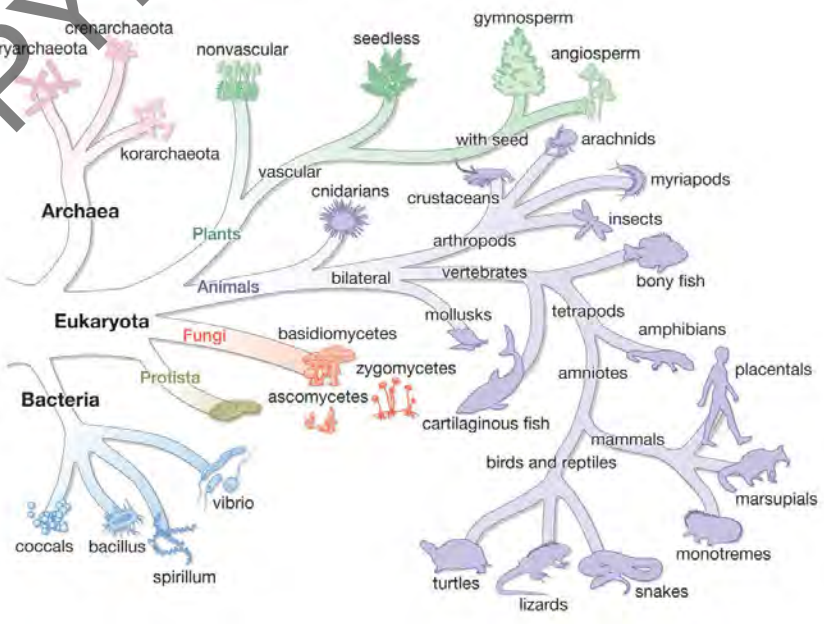


Figure 4.21: The three domains of life: Archaea, Bacteria, and Eukaryota.

Kingdom

A kingdom is the second highest taxonomic rank. There are five kingdoms of living things including Monera (bacteria and archaea), Animalia (animals), Plantae (plants), Fungi, and Protista (protists). Figure 4.22 shows the relative number of species in each kingdom of living things.

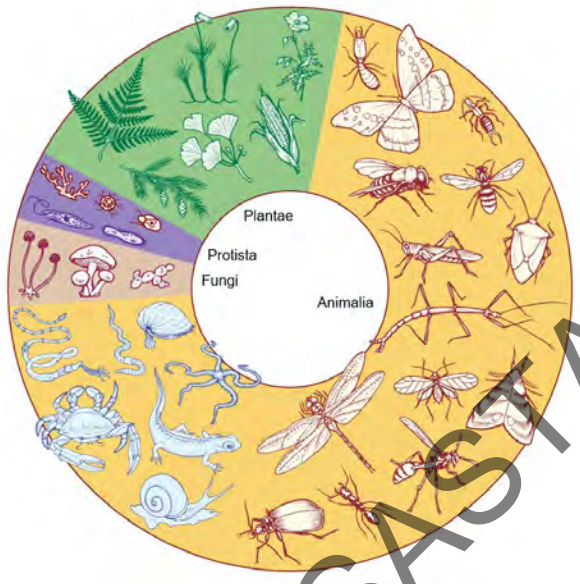


Figure 4.22: Relative number of species in each kingdom of living things.

Members of a kingdom are classified by a more extensive list of features including cell structure, cell organisation, body structure, nutrition class, and method of reproduction. Some features common to each kingdom of living things are identified below.

	Kingdom				
Feature	Monera	Animals	Plants	Fungi	Protist
Cell nucleus	No	Yes	Yes	Yes	Yes
Cell wall	Yes (peptidoglycan)	No	Yes (cellulose)	Yes (chitin)	Yes (cellulose)
Cell organisation	Unicellular	Multicellular	Multicellular	Unicellular and multicellular	Unicellular and multicellular
Body structure	Simple	Complex	Complex	Simple	Simple
Nutrition class	Autotrophs and heterotrophs	Heterotrophs	Autotrophs	Heterotrophs	Autotrophs and heterotrophs
Method of reproduction	Asexual	Mostly sexual	Sexual and asexual	Sexual and asexual	Asexual
Examples	Archaea and bacteria	Insects, birds, mammals	Mosses, ferns, conifers	Yeasts, moulds, mushrooms.	Protozoa, oomycetes.

Phylum

A phylum is the third highest taxonomic rank below domain and kingdom. Members of a phylum share features that differentiate them from members of other phyla.

Example 4.14

The kingdom of plants contains 12 phyla including bryophytes, filicinophytes, coniferophytes and angiospermophytes (Figure 4.23).

Figure 4.23: Examples of plant phyla.

Some features common to each phylum are identified in the table below.

	Phylum			
Feature	Bryophytes	Filicinophytes	Coniferophytes	Angiospermophytes
Body structures	No leaves, stem or roots	Have leaves, stem and roots.	Have leaves, stem and roots.	Have leaves, stem and roots.
Vascular tissue	None	Yes	Yes	Yes
Reproduction	Spores	Spores	Seeds (in cones)	Seeds (in fruit)
Other	Anchored by rhizoids	Have pinnate leaves	Have stems made from wood	Produce fruit and flowers
Examples	Mosses	Ferns	Conifers	Flowering plants

Example 4.15

The kingdom of animals is subdivided into those with a backbone, called **vertebrates**, and those without a backbone called **invertebrates**. All vertebrates belong to a single phylum called **Chordata**, whereas invertebrates are grouped into many different phyla including Cnidaria, Annelida, Mollusca and Arthropoda (Figure 4.24).

Figure 4.24: Examples of invertebrate animal phyla.

Some features common to each invertebrate phylum are identified in the table below.

	Phylum			
Feature	Cnidaria	Annelida	Mollusca	Arthropoda
Body symmetry	Radial	Bilateral	Bilateral	Bilateral
Body cavity	Mouth only (no anus)	Mouth and anus	Mouth and anus	Mouth and anus
Body segments	None	Segmented	None	Segmented
Other	Has stinging cells (cnidocytes)	Use peristalsis for locomotion	Many have a shell	Has an exoskeleton made of chitin
Examples	Coral, Jellyfish, Hydra.	Nereis, Earthworm, Leech.	Octopus, Snails, Squid.	Insects, Spiders, Crustaceans.

Class

A class is the fourth highest taxonomic rank below domain, kingdom and phylum. All members of a class share features that differentiate them from members of other classes of living things.

Example 4.16

The phylum Chordata, which includes all vertebrate animals, is subdivided into classes including fish, amphibians, reptiles, birds, and mammals (Figure 4.25).

Figure 4.25: Five classes of vertebrate animals.

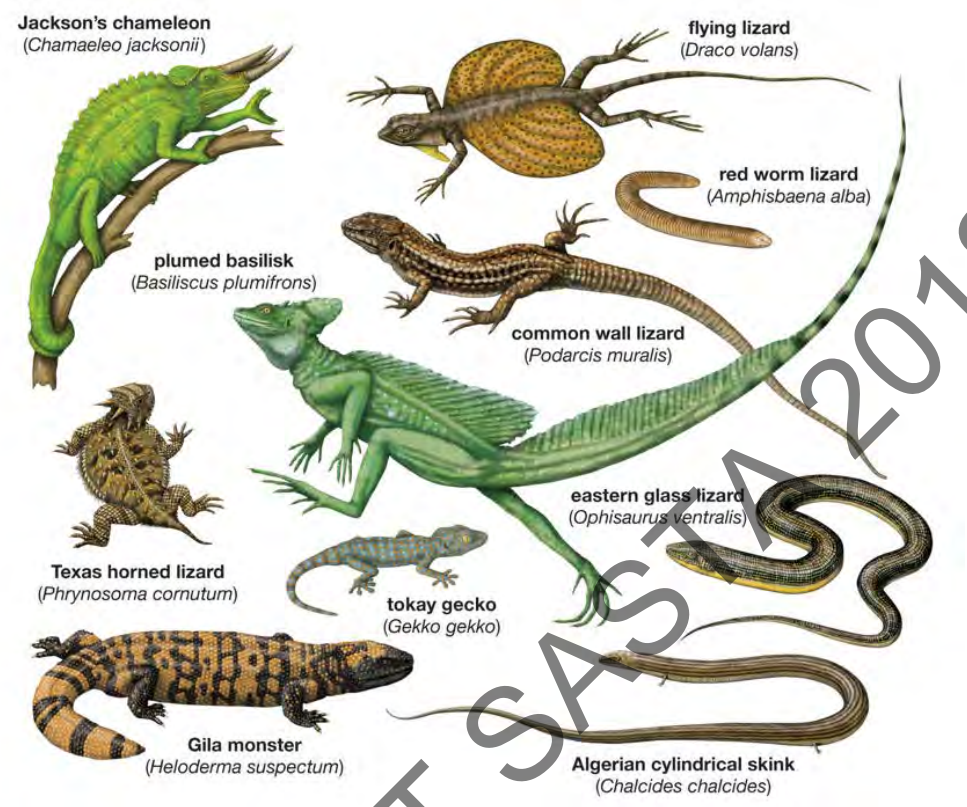
Some features common to each Cass of Chordata are identified in the table below.

	Class				
Feature	Fish	Amphibian	Reptile	Bird	Mammal
Body covering	Scales	Moist skin	Scales	Feathers	Hair
Respiratory organ(s)	Gills	Skin and lungs	Lungs	Lungs	Lungs
Temperature regulation	Ectotherm	Ectotherm	Ectotherm	Endotherm	Endotherm
Reproduction	External	External	Internal (lays soft eggs*)	Internal (lays hard eggs)	Internal (live births*)
Other	Live exclusively in water	Larvae develop in water	Three heart chambers	Have wings, and beaks	Nurse young with milk

*Some snakes produce live offspring. The echidna and the duck-billed platypus (monotremes) are mammals that lay eggs.

Question 97

The diagram below shows the common names and scientific names for several lizards.



(a) State the number of different Genera shown in the diagram.

_____ (1 mark) **KA2**

(b) Lizards have similar physical features.

(1) State two observable features common to all lizards in the diagram.

_____ (2 marks) **KA1**

(2) State the reason why lizards share similar features.

_____

_____ (1 mark) **KA1**

(c) Lizards are members of the reptilian Order of Squamata.

(1) Name the rank above Order in the taxonomic hierarchy.

_____ (1 mark) **KA1**

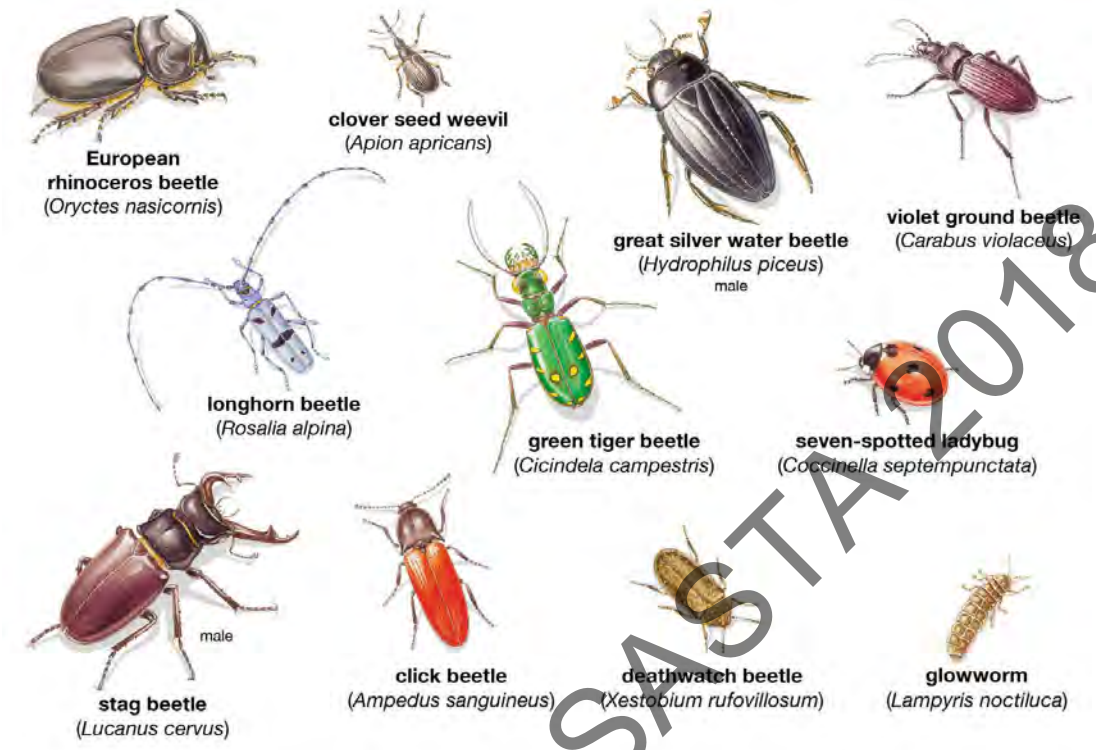
(2) Lizards all belong to the Phylum Chordata.

Identify the feature common to all members of the phylum Chordata.

_____ (1 mark) **KA1**

Question 98

Coleoptera is an Order of insects which includes beetles, weevils and ladybugs.



(a) Name the Genus of the seven-spotted ladybug.

_____ (1 mark) **KA2**

(b) Write the common name of *Carabus violaceus*.

_____ (1 mark) **KA2**

(c) There are similarities and differences between the species in the diagram.

(1) State two observable features common to all species in the diagram.

_____

_____ (2 marks) **KA2**

(2) State two differences between members of the genera Rosalia and Hydrophilus.

_____

_____ (2 marks) **KA2**

(d) Binomial nomenclature is an internationally agreed system of nomenclature.

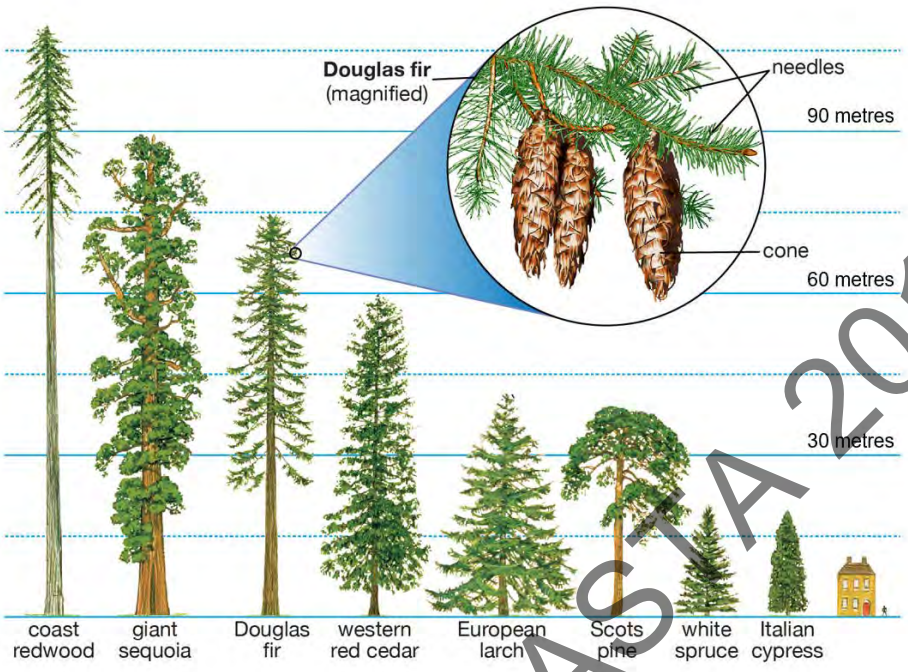
State two advantages of an internationally agreed system of nomenclature for living things.

_____

_____ (2 marks) **KA1**

Question 99

The diagram below shows several species of conifers.



(a) Write the common name of the second tallest conifer in the diagram.

_____ (1 mark) **KA2**

(b) State one limitation of using common names to identify living things.

_____

_____ (1 mark) **KA2**

(c) Conifers are members of the phylum Coniferophytes.

(1) State two features common to members of the phylum Coniferophytes.

_____

_____ (2 marks) **KA2**

(2) Coniferophytes are part of the kingdom of plants.

State two features common to members of the plant kingdom.

_____

_____ (2 marks) **KA2**

(d) Conifers are all members of the Domain Eukaryota.

State the feature of all members of the Domain Eukaryota.

_____ (1 mark) **KA1**

SOLUTIONS TO CHAPTER QUESTIONS AND REVIEW TESTS

Solutions: Chapter One				
Question	Part		Author's response	Marks
1	(a)	(1)	Movement	1
		(2)	Excretion	1
		(3)	Reproduction	1
		(4)	Respiration	1
		(5)	Metabolism	1
		(6)	Excretion	1
		(7)	Responding to stimuli	1
		(8)	Movement	1
		(9)	Respiration	1
		(10)	Growth	1
	(b)		A living thing is an organism that carries out life processes including movement, metabolism, respiration, growth, reproduction, responding to stimuli, and excretion. A non-living thing such as a material object or a deceased organism is incapable of carrying out one or more life processes.	1 1
2	(a)		Approximately 4 µm	1
	(b)		**Any one:** Presence of a nucleoid; No nucleus; No membrane-bound organelles;	1
	(c)		Provides rigidity and structural support to the cell.	1
	(d)		Nucleoid contains a single circular chromosome/loop of DNA.	1
	(e)	(1)	To release energy for life processes including growth, metabolism, movement and excretion.	1
		(2)	Structure Y increases the surface area of the cell membrane which increases the rate of aerobic respiration in the cell.	1
3	(a)		**Any two:** Cell wall; Cytoplasm; Cell membrane	1+1
	(b)		**Any two:** Nucleus; Mitochondrion; Chloroplast	1+1
	(c)		**Either:** Chloroplast Cell wall	1
	(d)		Increase in the size or number of cells in the body of *Chenopodium album*.	1
	(e)	(1)	Chloroplast	1
		(2)	Mitochondrion	1

17	(a)		Photosynthesis	1
	(b)	(1)	Simple diffusion	1
		(2)	By converting carbon dioxide to hydrogencarbonate ions inside the cell, the concentration of carbon dioxide remains higher in the extracellular space and lower inside the cell. This action preserves the concentration gradient and allows carbon dioxide to continue to diffuse passively into the cell for photosynthesis.	1 1
	(c)		**Either:** Thin cell wall; Large air spaces surround each cell which allows a high concentration of carbon dioxide to accumulate in the extracellular space.	1
18	(a)		Water diffuses passively across the membrane by osmosis from a region of higher to lower concentration. The diffusion of water occurs through membrane channel proteins called aquaporins as water is a hydrophilic solute that diffuses too slowly across the lipid bilayer.	1 1
	(b)		The concentrated sodium chloride solution is a hypertonic environment that increases the solute concentration in the extracellular space. Water diffuses out of the cell by osmosis from a region of lower solute in the cytoplasm to a region of higher solute in the extracellular space which reduces the volume of the cytoplasm as shown in the diagram.	1 1
19	(a)		Acetylcholine binds to the cholinergic channel receptor; Binding of acetylcholine opens the cholinergic channel allowing sodium ions to diffuse down the concentration gradient from a region of higher concentration in the extracellular space to a region of lower concentration inside the cell.	1 1
	(b)		Atropine binds to the cholinergic channel receptor which prevents the binding of acetylcholine; The cholinergic sodium channel remains closed which prevents sodium ions from diffusing into the cell.	1 1
	(c)		The affected individual has less control over muscle movements/weaker muscles.	1
20	(a)		Active transport; Both H^+ and Cl^- are transported against their respective concentration gradients from a region of lower concentration inside a parietal cell to a region of higher concentration in the canaliculus.	1 1
	(b)		Mitochondria are the site of aerobic respiration in eukaryotic cells such as gastric parietal cells. Large numbers of mitochondria are required to release sufficient energy for the active transport of materials between the cell and the extracellular space.	1 1
	(c)		Microvilli increase the surface area to volume ratio of the cell membrane which increases the rate of diffusion of hydrochloric acid into the stomach.	1

		(3)	Bacteria have consumed the available nutrients which prevents growth and metabolism; Bacteria have secreted a high concentration of waste materials which have inhibited growth and metabolism.	1 1
25	(a)		Chloroplast	1
	(b)		**Any one:** Phytoplankton synthesise oxygen in photosynthesis which supplies 50 to 85% of living things on Earth with oxygen for aerobic respiration; Phytoplankton are the primary food source, directly or indirectly, of most marine animals.	1
	(c)		As phytoplankton require sunlight for photosynthesis; The intensity of sunlight is greater near the surface of a body of water.	1 1
	(d)		The ocean temperature increases between September 21st and December 20th in the southern hemisphere as the seasons change from winter to summer. The concentration of chlorophyll increases in the southern hemisphere and decreases in the northern hemisphere with the changing seasons.	1 1
26	(a)		Hyphae are composed of many fungal cells connected by their cell walls.	1
	(b)		To break down dead and decaying material and provide soluble nutrients for plants and other microbes.	1
	(c)		Large molecules such as cellulase are excreted by exocytosis; Cellulase is packaged into vesicles in the Golgi apparatus in fungal cells before being transported and excreted across the cell membrane.	1 1
27	(a)		*Streptococcus thermophilus* and *Lactobacillus bulgaris* respire anaerobically, and oxygen will inhibit growth and metabolism.	1
	(b)		As the optimum temperature for growth of *Streptococcus thermophilus* and *Lactobacillus bulgaris* is between 37 and 44°C.	1
	(c)		Lactate fermentation/anaerobic respiration	1
	(d)		Low-temperature environment reduces the growth rate of bacteria; Fewer bacterial cells are present to secrete enzymes and waste materials that cause food spoilage in yoghurt.	1 1
28	(a)		Bacteria and fungi	1+1
	(b)		Microorganisms secrete enzymes that break down compounds in yoghurt into smaller nutrients that are absorbed into cells for metabolism and growth; Microorganisms then secrete waste materials that cause food spoilage.	1 1
	(c)		Vinegar is an acidic material that reduces the pH of the solution surrounding the food product. The low pH environment degrades the cell membranes and proteins of microorganisms which inhibits their growth.	1 1
	(d)		Saltwater provides a hypertonic environment; Water diffuses out of bacterial and fungal cells by osmosis when placed in a hypertonic solution which inhibits metabolism and growth.	1 1

Solutions: Review Test 3			
Question	Part	Author's response	Marks
1	(a)	M	1
	(b)	K	1
	(c)	L	1
	(d)	M	1
	(e)	K	1
	(f)	J	1
	(g)	L	1
	(h)	M	1
	(i)	J	1
	(j)	K	1
2	(a)	Deoxygenated blood is pumped from the right ventricle to the pulmonary capillaries gas exchange occurs; Oxygenated blood flows back to the heart via the left atrium.	1 1
	(b)	Any two: Epithelium in alveoli and endothelium in pulmonary capillaries has a thickness of one cell which reduces the diffusion path; Alveoli have a large surface area to volume ratio for gas exchange; Alveolar walls are moist which allows for rapid diffusion of oxygen and carbon dioxide; Alveoli have a rich supply of blood which maintains the concentration gradients of oxygen and carbon dioxide;	1+1
	(c)	Any two: The arterial end has a higher concentration of oxygen as this material diffuses into tissue cells at the arterial end of a systemic capillary; The venous end has a higher concentration of nutrients including glucose and amino acids from absorption of food through villi; The venous end has a higher concentration of carbon dioxide as this waste material diffuses into the blood at the venous end of the systemic capillary.	1+1
	(d) (1)	Filtration is the process by which glucose, amino acids, water and waste materials are forced under high pressure through the capillary walls of the glomerulus into Bowman's capsule. The purpose of filtration is to move materials from the blood into the renal tubule of the nephron where they are either selectively reabsorbed or removed by excretion.	1 1
	(d) (2)	Nitrogenous waste materials including urea and uric acid.	1
	(e) (1)	Bending increases the total surface area of the red blood cells that are in contact with the capillary wall which increases the efficiency and rate of gas exchange.	1
	(e) (2)	Proteins increase the solute concentration of the blood and lymph causing water to diffuse into blood and lymph capillaries by osmosis; The absence of proteins reduces the solute concentration in blood and lymph causing water to accumulate in tissue fluid rather than diffusing into blood and lymph.	1 1

	(h)	(1)	Increase in global average temperature due to increased emissions of greenhouse gases from human activities.	1
		(2)	The polar bear may experience prolonged periods of hunger due to a sharp reduction in its food source; The area of the Arctic covered by sea ice is decreasing which reduces the size of the hunting ground where polar bears prey on seals.	1 1
		(3)	To make predictions relating to the impact of environmental change caused by the decline in Arctic sea ice and to develop strategies to minimise the adverse effects of such change.	1
	(i)	(1)	Phytoplankton are primary producers that convert inorganic materials into nutrients through the process of photosynthesis.	1
		(2)	Approximately 10%; Energy is wasted as heat in respiration and through the incomplete digestion and absorption of phytoplankton by krill.	1 1
	(j)		The polar bear exerts control over the abundance of seals, whales, walrus, reindeer, rodents, seabirds, fish, and plants in its ecosystem. This prevents the population sizes of these species from increasing to unsustainable levels which would cause an imbalance in the food web.	1 1
	(k)		The two species are reproductively isolated and are prevented from mating/breeding as they do not share a habitat or breeding ground.	1
3			**Any three descriptions with explanations.** **Examples are given below.** **Each example below is worth 4 marks with 2 marks awarded per point.**	4+4+4
			Humans have modified the way that land is used in many ecosystems for mining, agriculture and urbanisation. These practices destroy habitats which increases the extinction rate as species are unlikely to find a sustainable food source, shelter or mates.	
			Humans have polluted every ecosystem on Earth through the extraction, processing, use and wasting of materials derived from the Earth. Pollution increases the extinction rate by modifying the abiotic components of an ecosystem and by weakening the immune systems of species.	
			Humans have exploited the natural resources of the Earth including fossil fuels and metals for fuels and materials, trees and plants for wood, medicines, and food and many animal species for food and trophies. Resource exploitation increases the extinction rate by decreasing the abundance of species, destroying habitats, and increasing pollution.	
			Humans have introduced non-native species into ecosystems for a range of purposes including hunting (sport) and controlling the abundance of native species. The introduction of non-native species increases the extinction rate by directly reducing the abundance of native species through predation.	
			Grammar, spelling, efficiency, clear and concise.	3

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