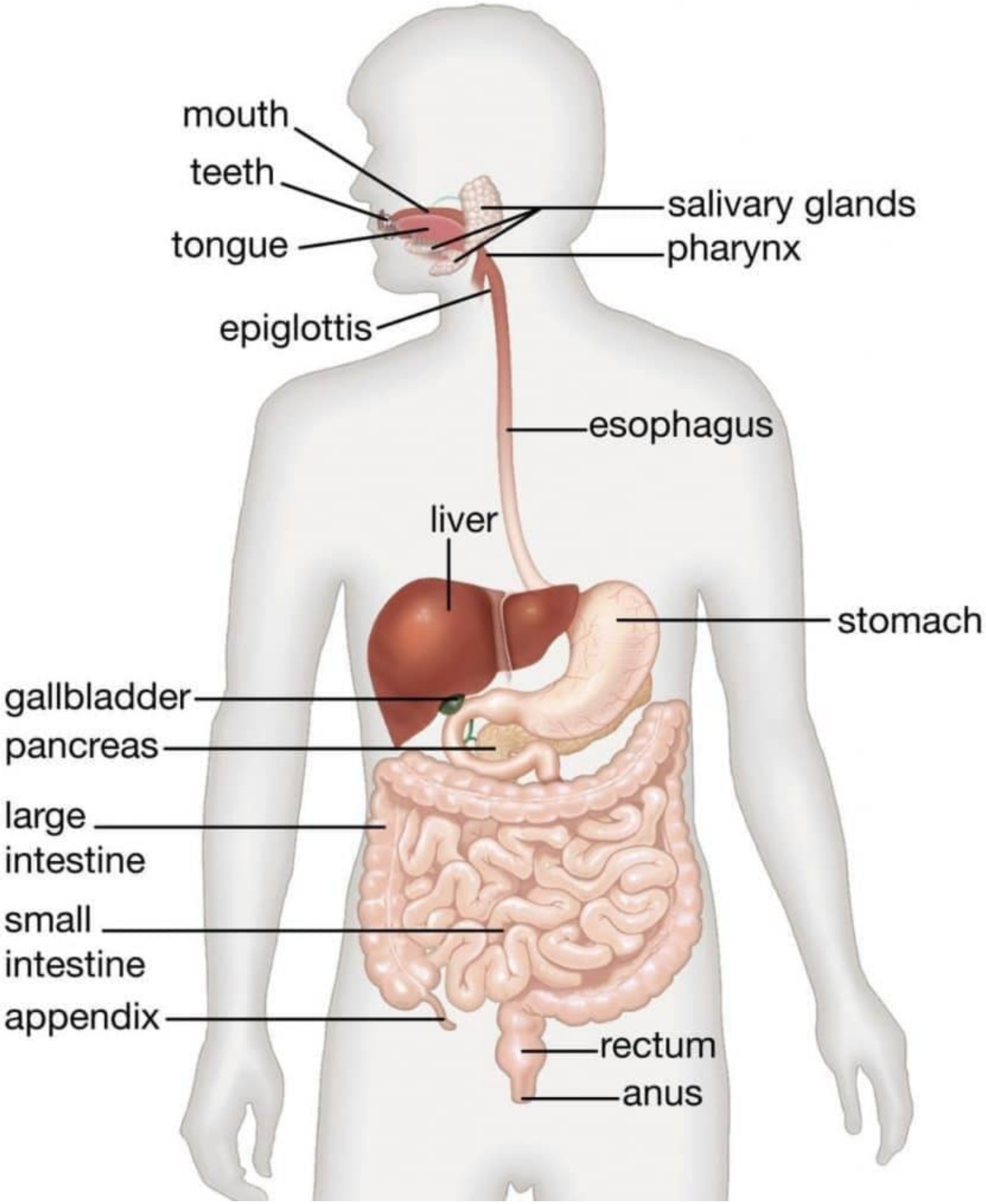
DIGESTIVE SYSTEM



The alimentary system is an organ system within humans and other animals concerned with ingestion, digestion and absorption of food as well as removal of wastes products (feaces).

The mouth, oesophagus, stomach and intestines are part of the alimentary tract or gastrointestinal tract.

The Mammalian Digestive System

The digestive system of a mammal consists of the alimentary canal and the associated glands. The parts of the alimentary canal are as follows

Mouth and Buccal Cavity

In the mouth food is masticated or broken down into small pieces by the teeth, salivary gland present in the mouth secrete saliva to soften the food. The saliva also contains enzymes.

Pharynx

The pharynx leads to the Oesophagus and to the trachea by the way of the larynx (voice box). The larynx bears the glottis (a slit-like opening) It is a common passage for food and air.

A flap-like cartilage, the epiglottis, lies above the larynx, just behind the tongue, and prevents food from entering the trachea or windpipe

Oesophagus or Gullet

It is a narrow muscular tube which connects the mouth to the stomach. Balls of food (boluses) pass through by peristalsis (zigzag movement), from the mouth to the stomach

Stomach

The stomach is a muscular organ located on the left side of the upper abdomen. It receives food from the oesophagus. Where the stomach joins the small intestine is the pyloric sphincter, a muscular valve whose contraction and relaxation allow food to pass into the small intestine.

The walls of the stomach are lined with gastric glands which secretes gastric juice. The gastric juice contains:

i. Pepsin (a protease), which breaks down large molecules of protein into small polypeptides

ii. Hydrochloric acid (HCL) to maintain an optimum PH (1 – 2, 5) for the functioning of the protease. The acid also kills bacteria.

Organs and Glands associated with the Gut

Liver and the gall bladder

The liver lies immediately below the diaphragm to the right side of the body. It is dark red in colour and is made up of four lobes. It is the largest gland in the body.

The liver secretes bile (greenish–yellow alkaline fluid) which contains bile salts and pigment. The bile pigment gives the bile its characteristics colour. Bile aids the digestion of fats. The bile is stored in the gall bladder

Pancreas

The pancreas lies in the loop of the duodenum. The pancreatic duct connects the pancreas to the duodenum. The bile duct from the gall bladder and the pancreatic duct from the pancreas opens into the duodenum. The pancreas secretes the pancreatic juice which contains digestive enzymes.

The pancreas also secretes insulin, this hormone plays an important role in the regulation of blood sugar.

Feeding Mechanisms of Some Animals

The mammalian digestive system shows the highest degree of modification according to the feeding habits. The different categories of feeding habits are

1. Filter feeding
2. Fluid feeding
3. Deposit feeders
4. Insect feeders
5. Parasitic feeders
6. Saprophytic feeders

Parasitic Feeding

In parasitic feeding, an organism (parasite) lives on the body surface or inside the body of another type of organism (host). The parasite obtains food directly from the host without contributing anything in return. The host is harmed during the feeding process.

- Examples of parasites are lice, tick, tapeworm fleas.
- Ectoparasites e.g lice, fleas, tick lives on the body surface.
- Endoparasites like tapeworm, round worm lives insides the body of the host.

Saprophytic Feeding

This mode of feeding is carried by organisms that do not possess chlorophyll.

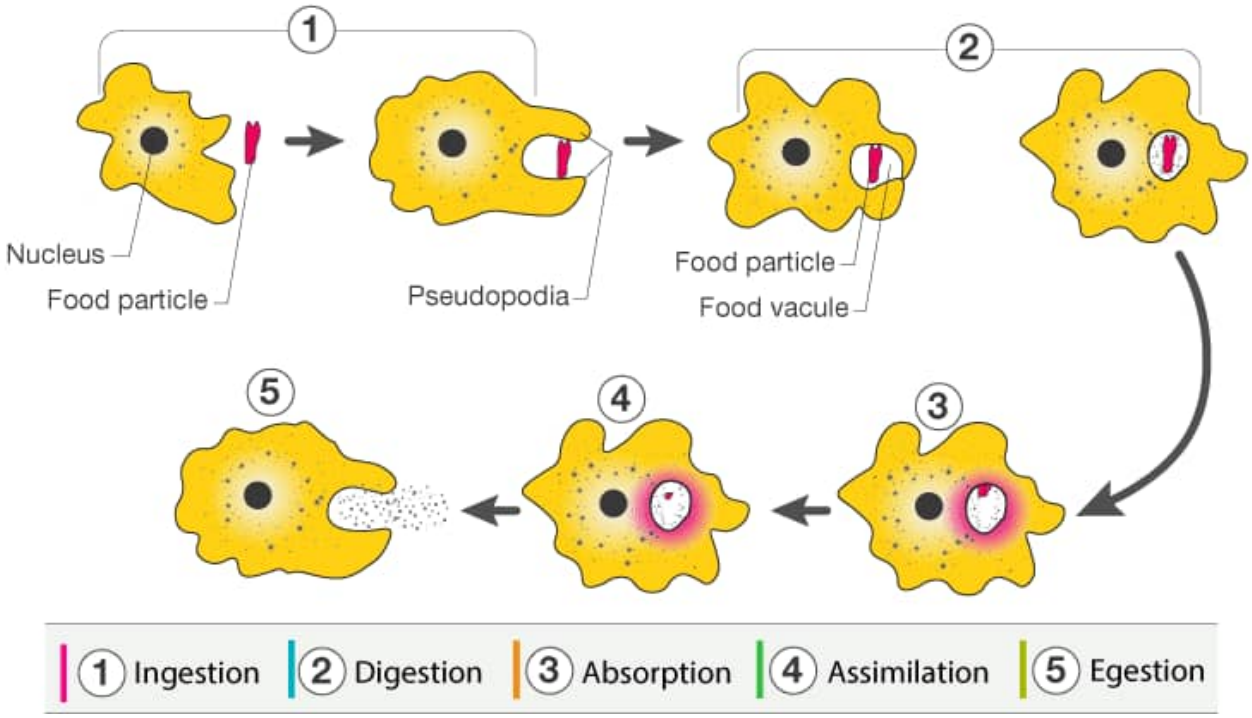
These plants feed on dead and decaying organic matter. Examples of saprophytic feeders are Mucor, Mushroom, Rhizopus. Root-like structures known as Rhizoids, found in fungi, secrete digestive enzymes from their cells to the dead organic matter. Digestion is extracellular i.e. It takes place outside cells of the saprophytic plants. The nutrients are then absorbed by the cells.

Saprophytic fungi

Feeding Mechanism in Protozoa e.g Amoeba

Amoeba feeds on algae such as diatoms and *Chlamydomonas.*

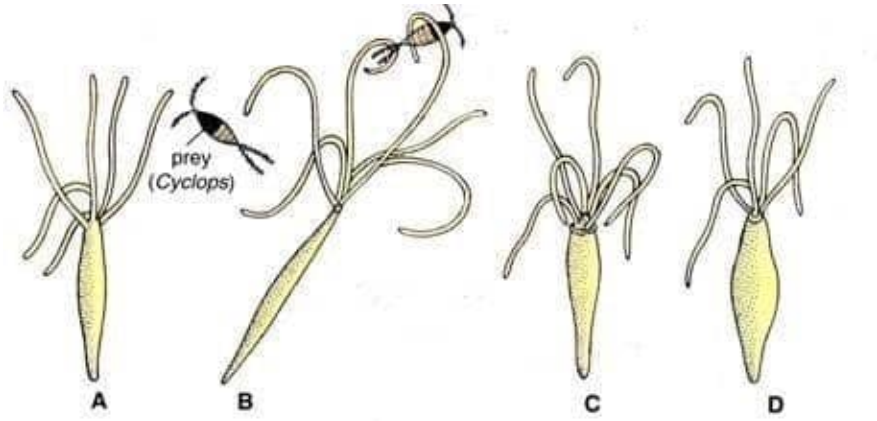
When Amoeba comes in contact with its food, it thrusts out its pseudopodia in the direction of the food and surrounds It with a drop of water forming the food vacuole . The food particle is carried around the cell and digested. Digested food diffuses into the cytoplasm. Nutrients are assimilated and the undigested food is egested.



Process of Feeding in Amoeba

Feeding Mechanism in Hydra

Hydra feeds on small aquatic organisms such as water fleas, insect larvae etc. When a hydra is hungry, it stretches out the tentacles, when it comes in contact with prey, the nematocysts discharge their stinging threads which pierces and injects a poisonous substance into the body of the prey. The prey is then paralysed and carried to the mouth by the tentacles. Once the food is in the enteron digestive enzymes are secreted by the endodermal cells to digest it. The digested food is absorbed while the undigested food is passed out through the mouth.



Feeding Process in Hydra

Insects feeders: (Insectivorous / carnivorous plants)

These are plants that obtain energy by feeding on small insects. They have developed special structures to trap their prey. Examples of insectivorous plants are pitcher plants, venus flytrap, sundew.

The Pitcher Plant

In the pitcher plant, some of its leaves are modified to form a pitcher – like a container; a deep cavity filled with digestive liquid. The inner walls of the containers are slippery and smooth. Once insects are trapped, they are unable to come out.

At the bottom, they are digested by a pool of liquid containing digestive enzymes.

Pitcher Plant – Flesh Eating Plant

TRANSPORT SYSTEM I

Principles of diffusion and osmosis

Diffusion:

Diffusion is defined as the movement of molecules of substances from a region of higher concentration to a region of lower concentration of the molecules. Diffusion occurs in all the states of matter; solid, liquid, and gaseous states. Diffusion is driven by concentration gradient which tends to adjust the component concentration until equilibrium is established

Osmosis

Osmosis is defined as the movement of fluid water molecules from a dilute solution into a concentrated solution through a selectively permeable membrane. When a selectively permeable membrane separates two fluids spaces. The fluid would flow from an area of lower concentration of the solute to one of the higher concentration of the solute in order to achieve equilibrium such that the osmotic pressures become balanced.

Osmosis and diffusion are biophysical processes involved in the transport of materials.

Transport System

Need for transportation

In small unicellular organisms, the surface area to volume ratio is large. Diffusion is sufficient to transport materials between the cell and its environment.

As organism increases in size, simple diffusion is not enough to transport materials from the environment to the cell.

Hence, the need for a transportation system. In animals, the transport medium is blood which transports substances within the blood vessels. In plants, the xylem and the phloem make up the vascular system through which materials are transported.

Transport System in Animals

The transports system provides an efficient means through which substances are distributed within the body. As mentioned earlier, simple diffusion is not sufficient to transport materials from one part of the body to another because the surface area to volume ratio for larger organisms including man is small.

Transportation in man is made possible by the lymph and blood.

Materials for transportation in man are

(i) Excretory products such as Urea, salts carbon – dioxide and water.

(ii) Gases such as oxygen

(iii) Food materials such as glucose, amino acids, fatty acids and glycerol, vitamins and mineral salts

(iv) Antibodies and

(v) Hormones

Structure of the Mammalian Blood

The mammalian bloods consist of the solid and the liquid component.

The liquid portion of the blood is known as the plasma. The solid components which are the blood cells are suspended in the plasma.

Plasma

The plasma is made up of water (about 90%) salts and protein. More than 50% of the blood is plasma.

Constituents of plasma

(i) Water about 90%

(ii) Blood proteins such as albumins, fibrinogen, globulins prothrombin

(iii) Hormones, antibodies, metabolic wastes e.g urea, creatinine

Red Blood Cells or Corpuscles (Erthrocytes)

Shape: The mammalian red blood cell is circular in shape and biconcave

(i) There are about 5million RBC per cm^3 of blood

(ii) Newly formed red blood cells lack nucleus

(iii) Nucleus is absent in older red blood cells but present in newly formed cells

(iv) The life- span is about 120days

(v) They are mainly produced in the bone marrow

(vi) They are red in colour due to the presence of haemoglobin

Function:

The pigment haemoglobin helps to transport oxygen.

Red Blood Cells

White Blood Cells or Corpuscle (Leucocytes)

(i) They are usually larger in size than the red blood cells but fewer in number (about 7000 per cm^3 of blood)

(ii) They are nucleated

(iii) They are amoeboid in shape

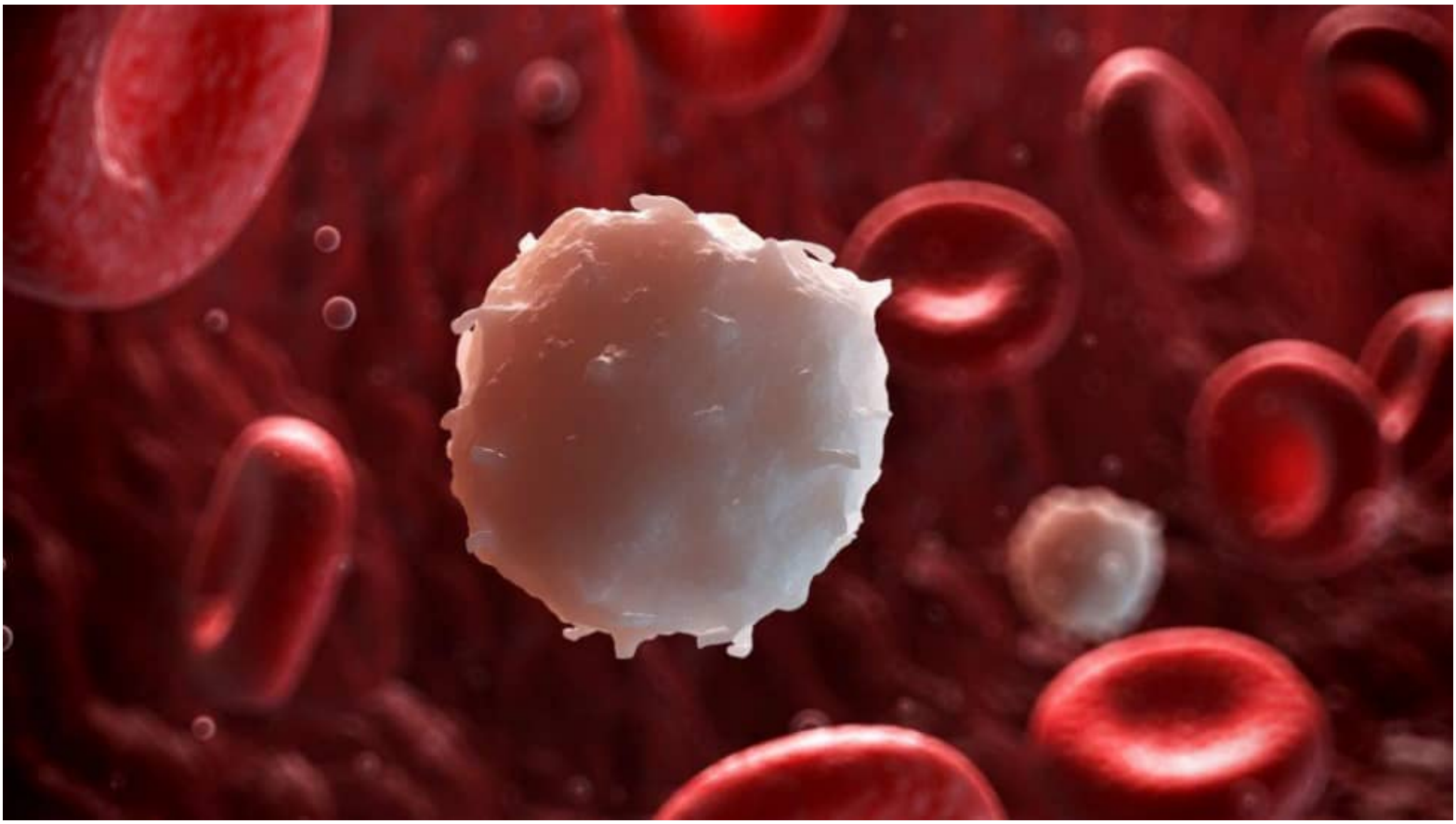
(iv) They are colourless

(v) They are formed in the red bone marrow

(vi)We have different forms of white blood cells; phagocytes, lymphocytes

Function:

Fight infection/ germs either by ingesting bacteria or produce antibodies

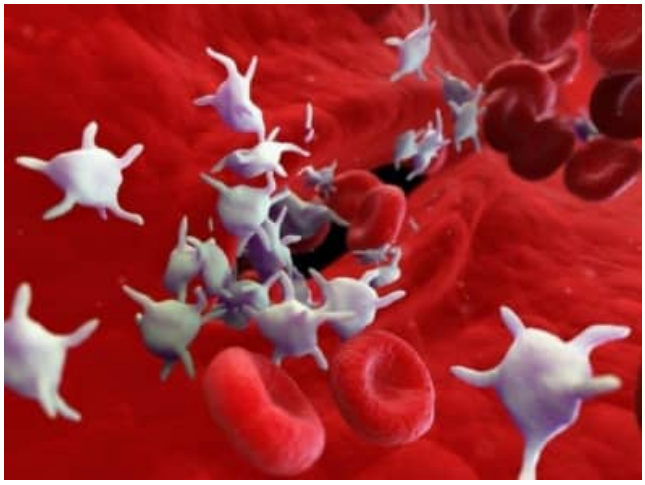


White-blood-cell

Platelets or Thrombocytes

These are cytoplasmic bodies budded off large cells in the red bone marrow in other words, they are cell fragments formed in the bone marrow from megakaryocytes.

- They have different shapes:
- They are usually fewer in number than the red blood cells
- They play an important role in the blood clotting



Functions of the Blood

Blood transports the following substances; gases namely oxygen and carbon – dioxide, digested food substances (nutrients) waste products

The blood performs three main functions

(i) Protection

The blood protects the body in the following ways

(a) White blood cells or leucocytes destroy invading microorganism

(b) Proteins and antibodies destroys pathogenic substances

(c) Platelets initiate clotting of blood

(ii) Regulation

(a) The blood helps to regulate the PH by interacting with acids and bases

(b) Water balances by transferring water to and from tissues

(c) Regulates body temperature by distributing heat

(iii) Transportation

Blood transports the following substances

(a) Haemoglobin in the red blood cells helps to transport oxygen in form of oxy-haemoglobin

(b) Blood also transports carbon – dioxide between the lungs and the rest of the body

(c) End products of digestion such as glucose, amino acids, fatty acids and glycerol and other food substances such as mineral salts, vitamins are also transported by the blood .

(d) The blood transports hormones, from the glands where they are produced to their target cells.

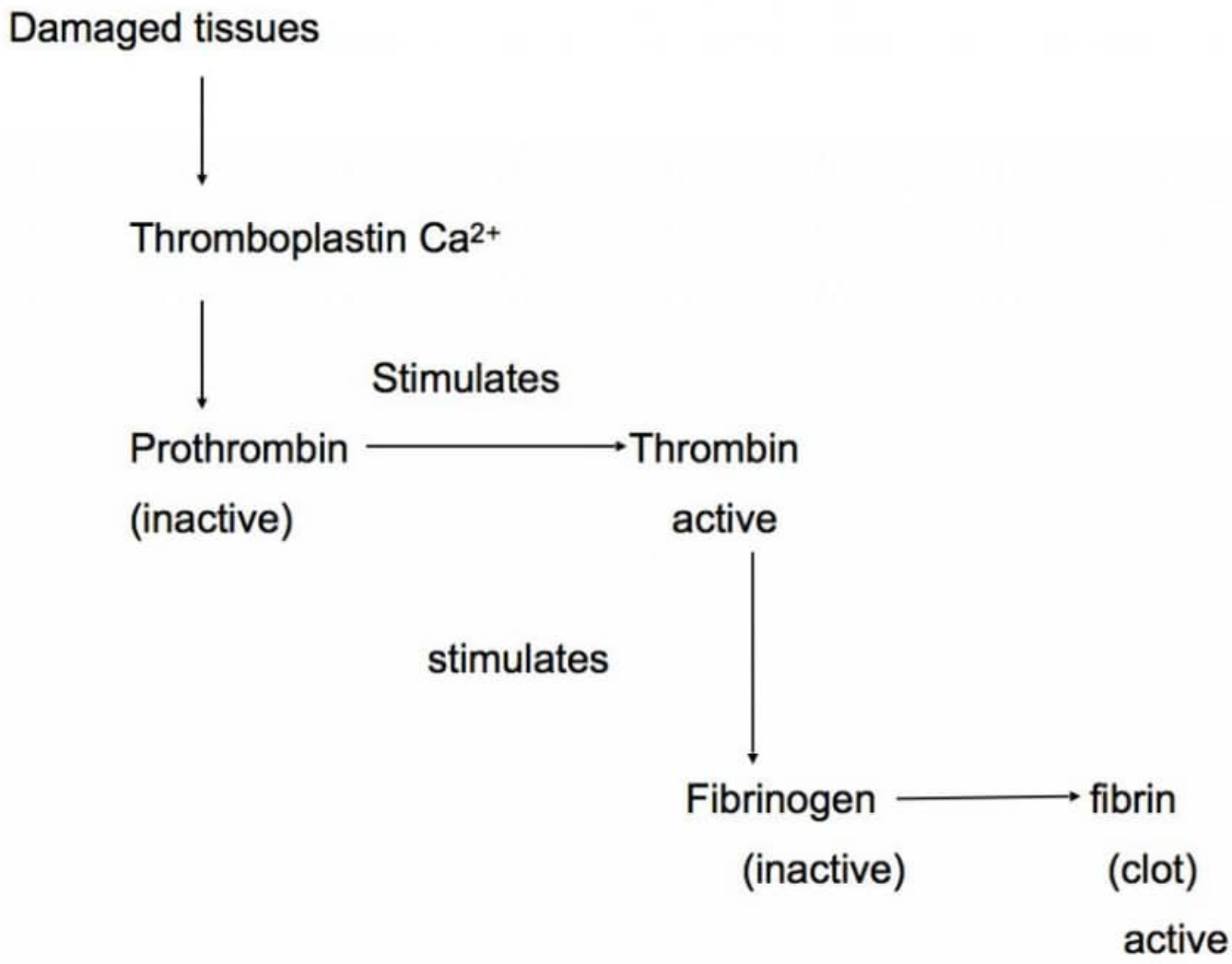
(e) The blood distributes heat round the body and also helps to regulate body temperature

(f) Excretory products such as carbon – dioxide urea from the cells that produce them to various excretory organs for elimination.

Clotting of Blood

Clotting of blood is a complex mechanism which begins with the release of clotting factors called thromboplastin from the platelets.

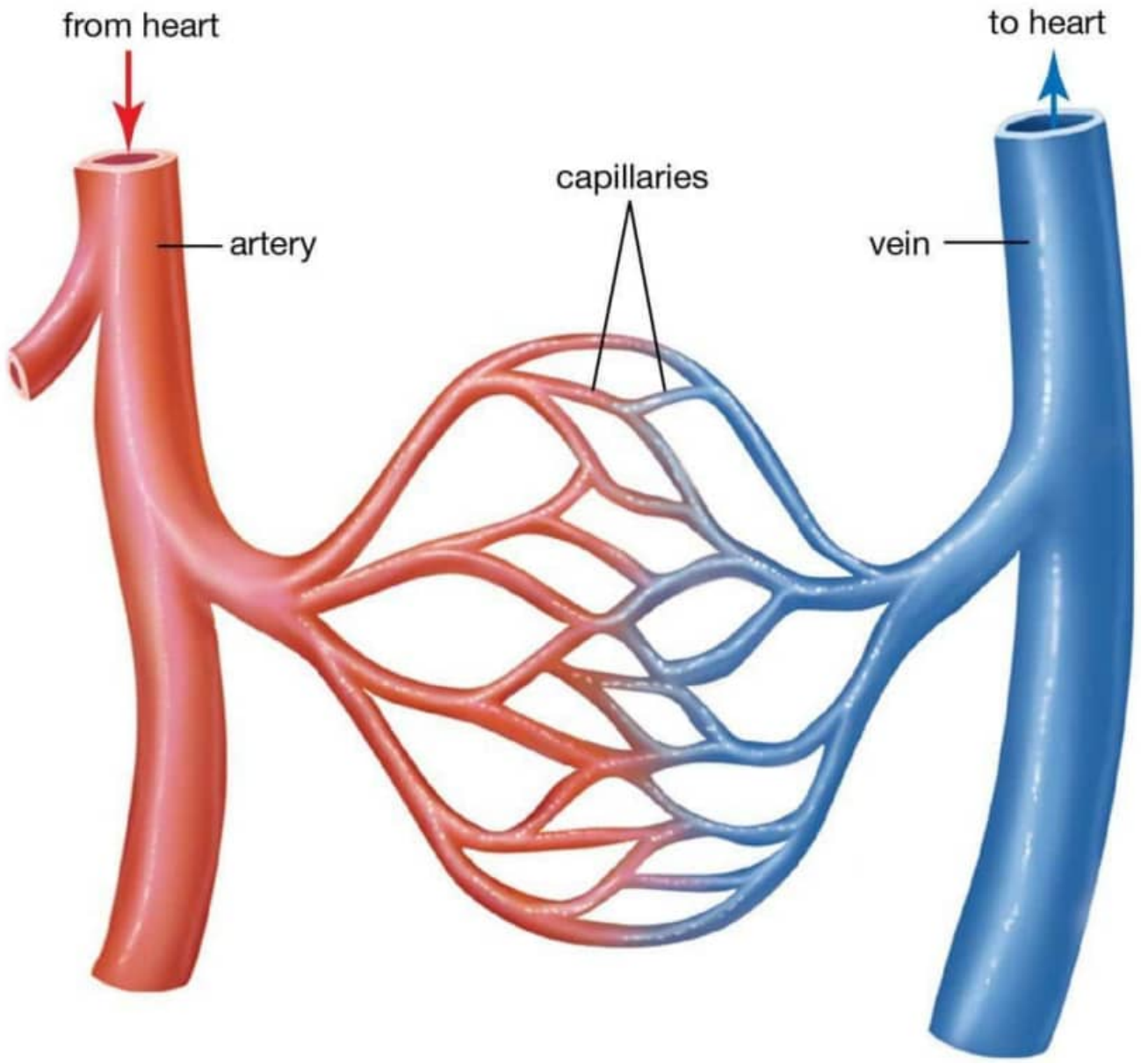
The pathway for the clotting of blood is shown below



TRANSPORT SYSTEM II

Structure of Arteries, Veins, and Capillaries

Blood vessels consist of arteries, veins and capillaries.



Arteries, Veins, and Capillaries

Arteries

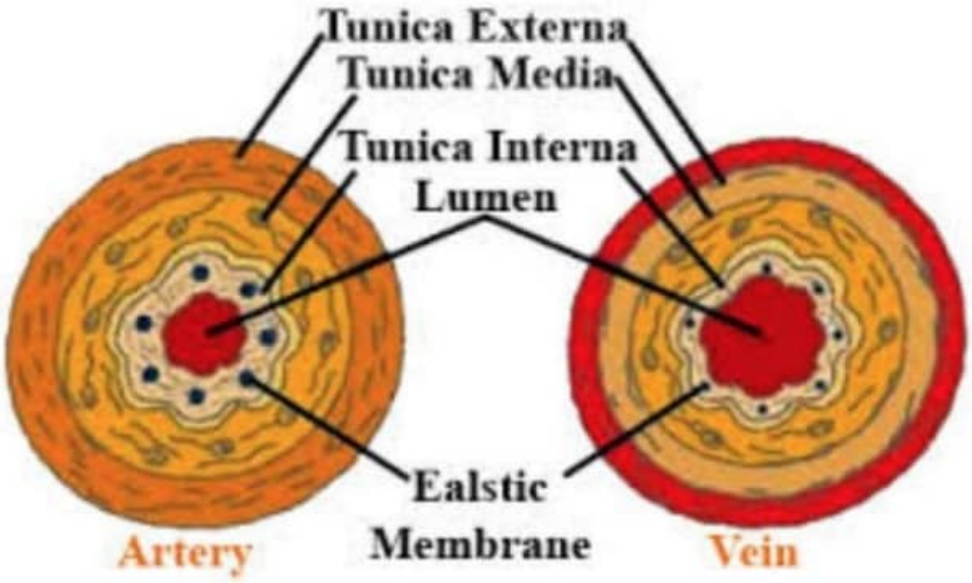
Arteries are blood vessels which carry blood away from the heart. They have thick and elastic walls which can withstand high pressure from the blood flowing in it.

Arteries are situated deep in the body and do not usually have valves. Arteries divide into smaller vessels called arterioles.

Pulse is readily detectable in the arteries. They have a narrow lumen which increases as a pulse of blood passes through.

Veins

They have thin walls that are not as elastic as the walls of the arteries. They have large lumen. Blood flows with little pressure in the veins hence the presence of valves in them to prevent backflow of blood. Veins divide into smaller vessels called venules.

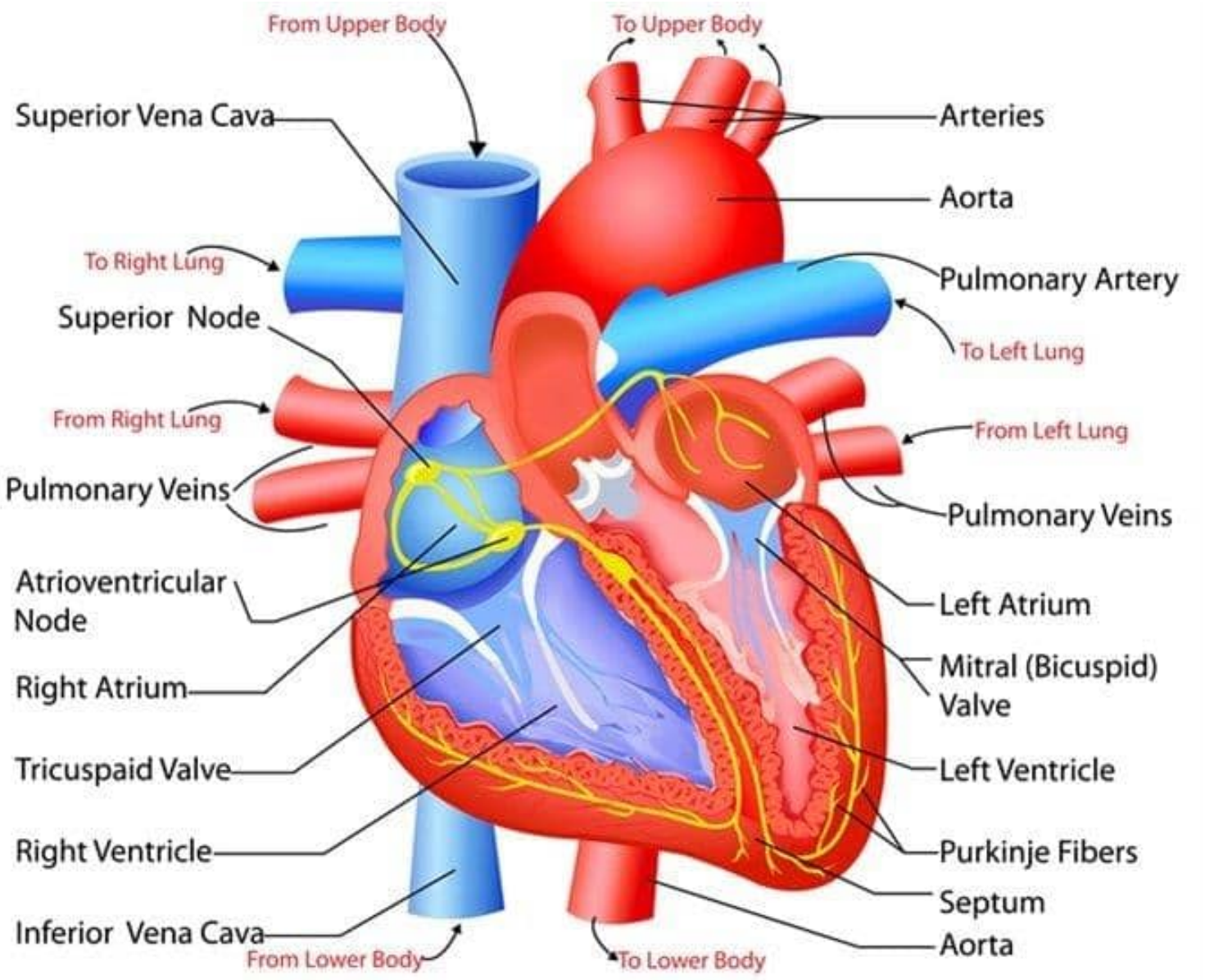


Capillaries

Capillaries are usually one cell thick, with permeable wall. They do not have muscle or elastic tissue. Valves are absent in capillaries. The permeable wall of the capillaries allows diffusion of materials between the capillary and the surrounding tissue. Blood travels slowly here.

The capillary links the artery with the vein, they are found between the arteries and the veins around tissues & organs

Structure of the Heart



The heart is a muscular pumping organ. It is roughly the size of a man's closed fist. The heart is enclosed in a pericardial sac.

The mammalian heart is divided into four chambers. The right and the left artria (singl. atrium) which are the upper chambers and the right and left ventricles which are the lower chambers.

A central wall known as the septum separates the left part of the heart from the left.

Between the right artrium and left ventricle is an aperture guarded by a valve known as tricuspid valve. This valve is made up of three cusps. It allows blood to flow in one direction i.e from the right artrium to the right ventricle

Between the left artrium and the left ventricle is another valve with two cusp guarding the aperture. This valve is known as Bicuspid or mitral valve. The cusps are attached to the inner walls of the ventricles by chordae tendinae, a special fibrous non – elastic cord.

The Aorta (the largest artery in the body) and the pulmonary artery are equipped with semilunar valves which allow blood to flow out of the heart into the arteries.

The heart pumps blood around the body. The blood travels from the heart through the arteries and returns in veins. As blood enters an organ, the arteries divides into smaller arterioles which supply the capillaries.

The blood moves more slowly in the capillaries allowing the exchange of materials such as glucose, oxygen, carbon dioxide, and other wastes. Blood leaves the organs through the Venules which transfers it to the veins.

Differences between the Arteries and Veins

Below are Differences between the Arteries and Veins

S/N	Arteries	Veins
1	They carry blood away from the heart.	They carry blood to the heart.
2	It carries oxygenated blood except for the Pulmonary artery.	It carries deoxygenated blood except for the pulmonary vein.
3	Arteries have thick muscular walls.	Veins have thin, less muscular walls.
4	Walls of the arteries are elastic with fibre and fibrous tissues.	The walls and non-elastic.
5	It has a narrow lumen.	It has a wide lumen.
6	Valves are absent except the semi – lunar valves.	Valves are present.
7	Arteries are situated deep in the muscles.	Veins are superficially located.
8	Pulse is readily detectable in the arteries.	Pulse not readily detectable.
9	Blood flows under high pressure.	Blood flows under low pressure.
10	Blood in the arteries is pink or bright colour.	Blood in the veins is dark red in colour.

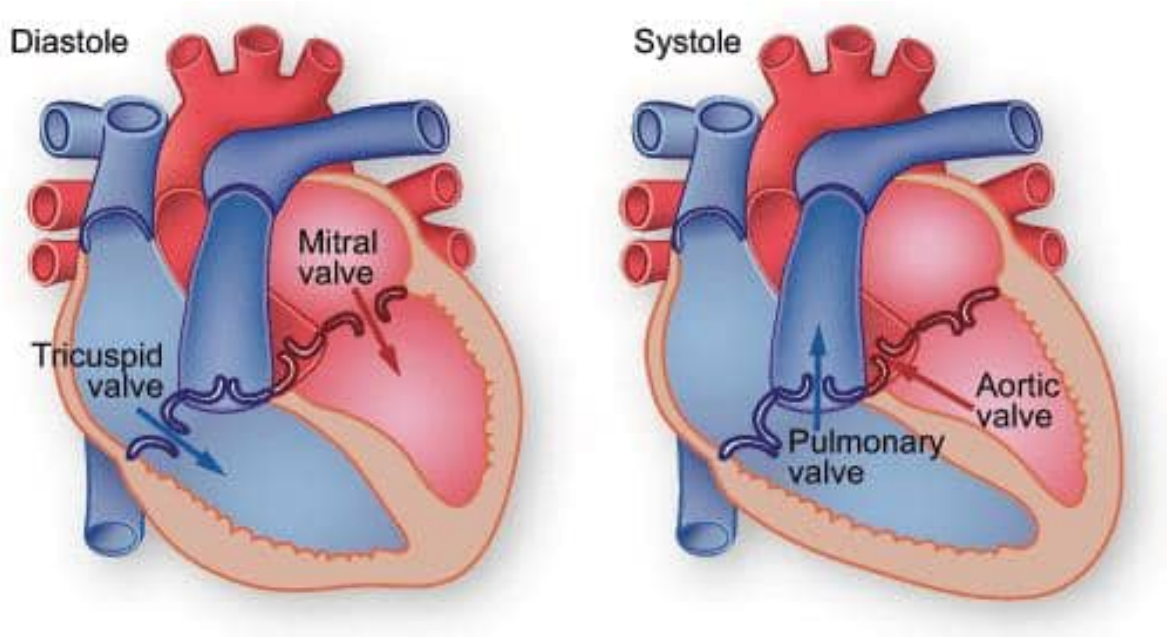
TRANSPORT SYSTEM III

Circulation of Blood

The flow of blood round the body is known as blood circulation. The Circulation of Blood is caused by the pumping action of the heart. Pressure usually fluctuates with the heartbeat. The pressure wave can be felt as a pulse or heartbeat. In mammals blood flows in circuits. Blood passes through the heart twice in one circulation.

Heartbeat

It can occur in two stages; diastole and systole.



Diastole:

This is the first stage of the heartbeat. The series of events that happens during diastole can be summarized below.

i. Blood enters the artria of the heart through the vena cava creating a high pressure in the blood contained in them.

ii. The pressure forces the valves, bicuspid and the tricuspid valve to open into the ventricles; deoxygenated blood flows into the right ventricle from the right atrium while oxygenated blood flows into the left ventricles from the left artrium.

iii. The ventricles contracts when they are full with blood closing the bicuspid and the tricuspid valves.

Systole

1. This involves the contraction of the ventricles
2. As the ventricles contracts, blood is forced out through the semi-lunar valves into the main arteries
3. Oxygenated blood flows into the AORTA from the left ventricle
4. Deoxygenated blood flows into the pulmonary artery from the right ventricle
5. As the events occur, blood fill the artria again and the process repeats itself

Blood circulates through the heart coronary circulation or through the kidneys (renal circulation or through the liver (hepatic circulation)

The major blood vessels are

i. Pulmonary Artery

ii. Pulmonary vein

iii. Renal vein

iv. Renal artery

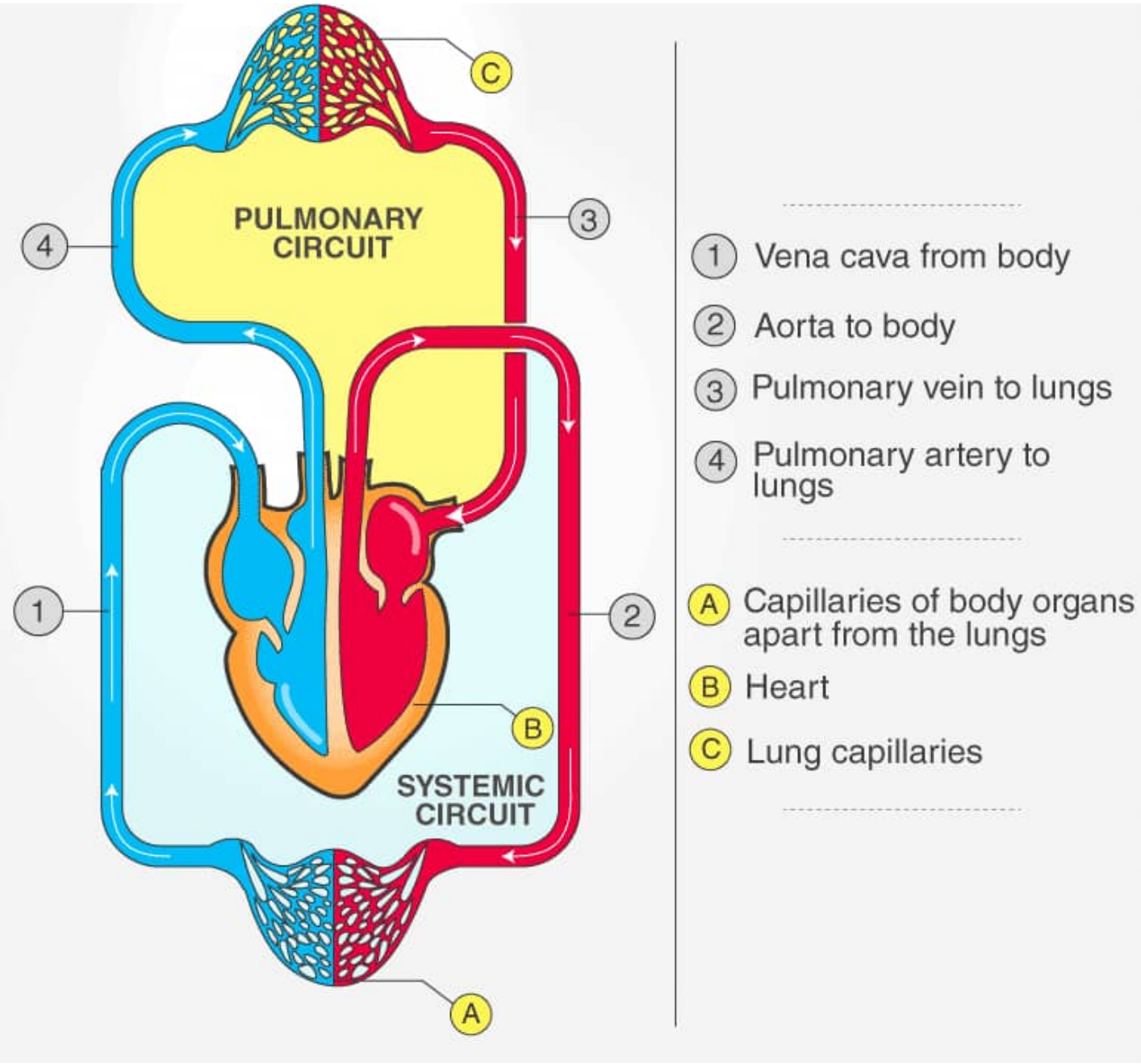
v. Aorta

vi. Hepatic portal vein

vii. Vena cava

Mechanism of Transportation in Higher Animals

Mammals exhibit double circulation.



Blood passes through the heart twice in one complete circulation. In other words we have two different types of circulation.

i. Pulmonary Circulation:

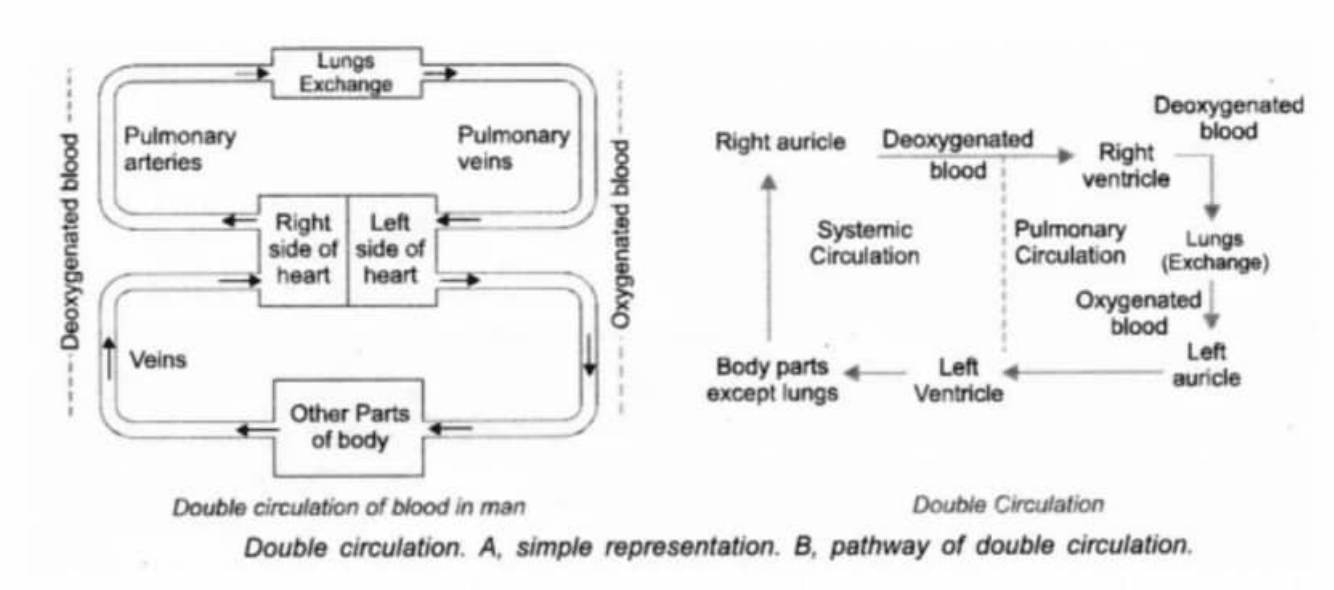
This is the flow of the blood between the heart and the lungs

Deoxygenated blood flows through the pulmonary artery to the lungs for oxygenation and back to the heart through the pulmonary vein oxygenated. The essence of this type of circulation is to oxygenate the blood and at the same time eliminate carbon – dioxide from the lungs

ii. Systemic Circulation:

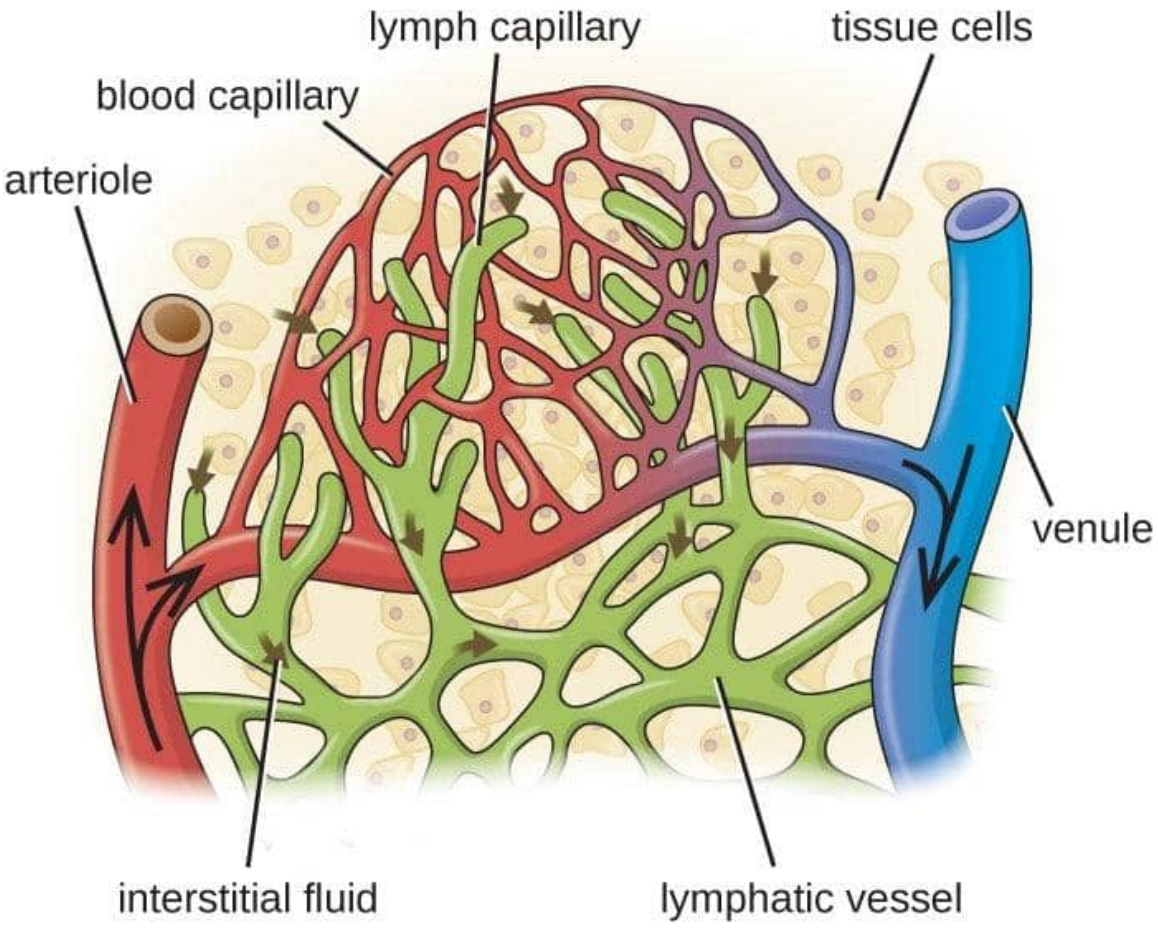
This is the flow of blood between the heart and all parts of the body.

Oxygenated blood leaves the left part of the heart through the Aorta to all parts of the body except the lungs. The veins; superior vena cava and inferior vena cava carry blood from all parts of the body to the heart (right artrium). This is called systematic circulation



Double circulation. A, simple representation. B, pathway of double circulation.

Tissue Fluid or Lymph



Lymph is a clear – to – white fluid mode of white blood cells especially lymphocytes. The lymph system is a major part of the body's immune system.

When blood flows from the arteries to the capillaries in organs and tissues, some substances, antibodies, hormones, and oxygen diffuse into the tissues through the thin walls of the capillaries. This fluid is referred to as tissue fluid or lymph.

The tissue fluid supplies nutrients, oxygen to cells in tissues and organs and collects wastes products e.g CO_2.

The exchange of materials between the blood and tissues takes place during capillary circulation.

Open and Closed Circulation

The circulatory system can either be open or closed depending on whether blood flows freely in a cavity or is contained in vessels.

Open Circulation

It is found in arthropods, Molluscs, the heart pumps blood into a cavity called the haemocoel.
Organs in contact with haemocoel exchange materials with the blood. The blood flows back to the heart in the vessels.

Closed Circulation

Occurs in higher animals such as man. It is found in all vertebrates and some invertebrates. Blood circulates unidirectional from the heart, to all parts of the body and back to the heart. Mammals have double circulation while some vertebrates with one auricle and one ventricle such as fish have single circulation where blood flows through the heart in each circulation round the body.

TRANSPORT IN PLANTS

Transport in Plants

Materials transported in plants include oxygen, carbon – dioxide, mineral salts, manufactured food, water and hormones. These substances are transported in solution while the gases such as oxygen and carbon – dioxide diffuse from the atmosphere through the stomata of the leaves and the lenticels in the stem.

In unicellular organisms such as Chlamydomonas substances are transported by cyclosis or protoplasmic streaming.

In higher plants, transport takes place through the vascular bundles.

The vascular system consists of

(i) Xylem tissue: The xylem tissue is made up of

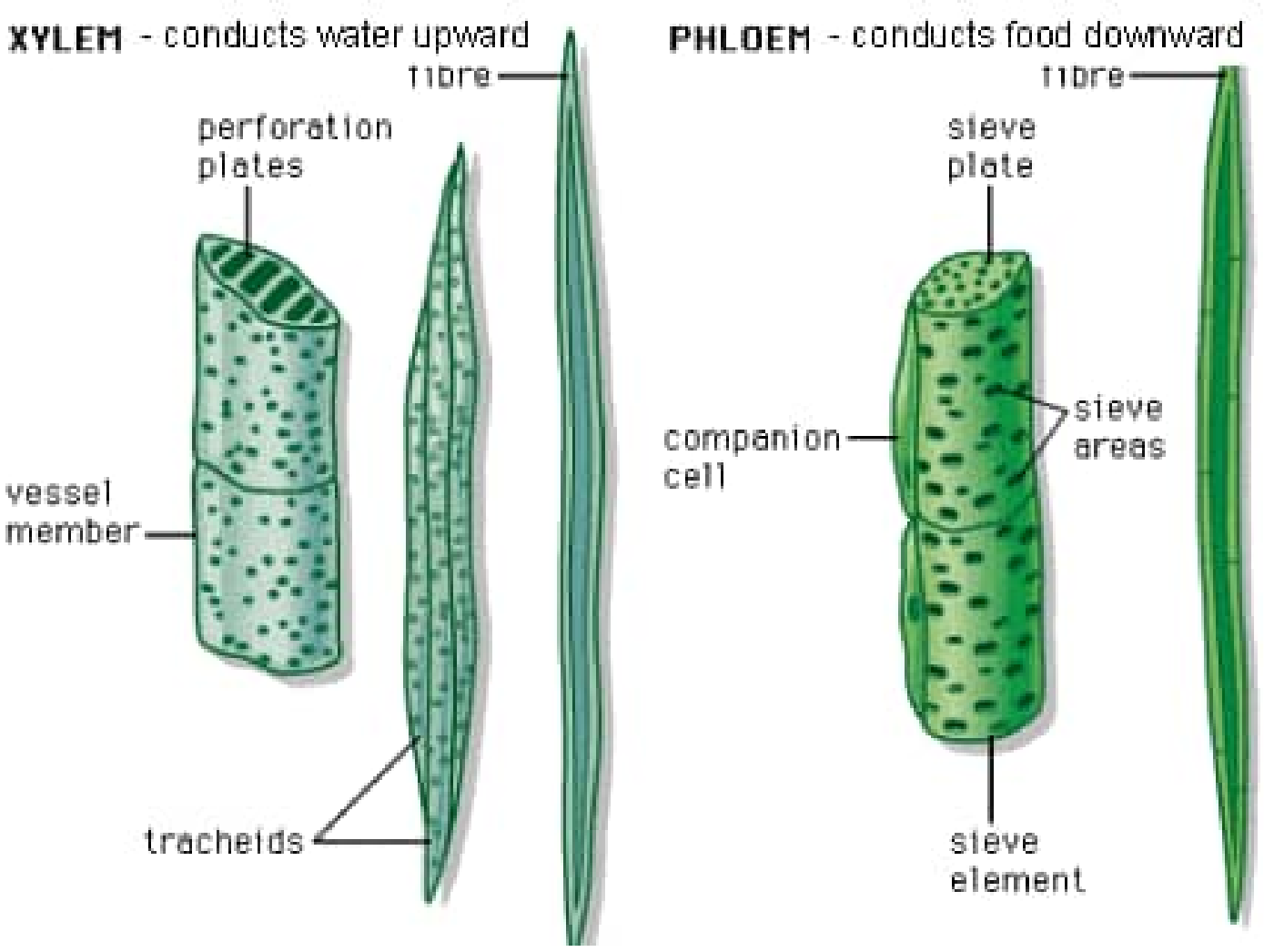
(a) Xylem parenchyma

(b) Xylem fibres

(c) Xylem tracheids

(d) Xylem vessels

The Xylem tracheids and the xylem vessels are responsible for the transport of mineral salts and water from the soil to the leaves.



(ii) **Phloem tissue**: The phloem tissue is made up of

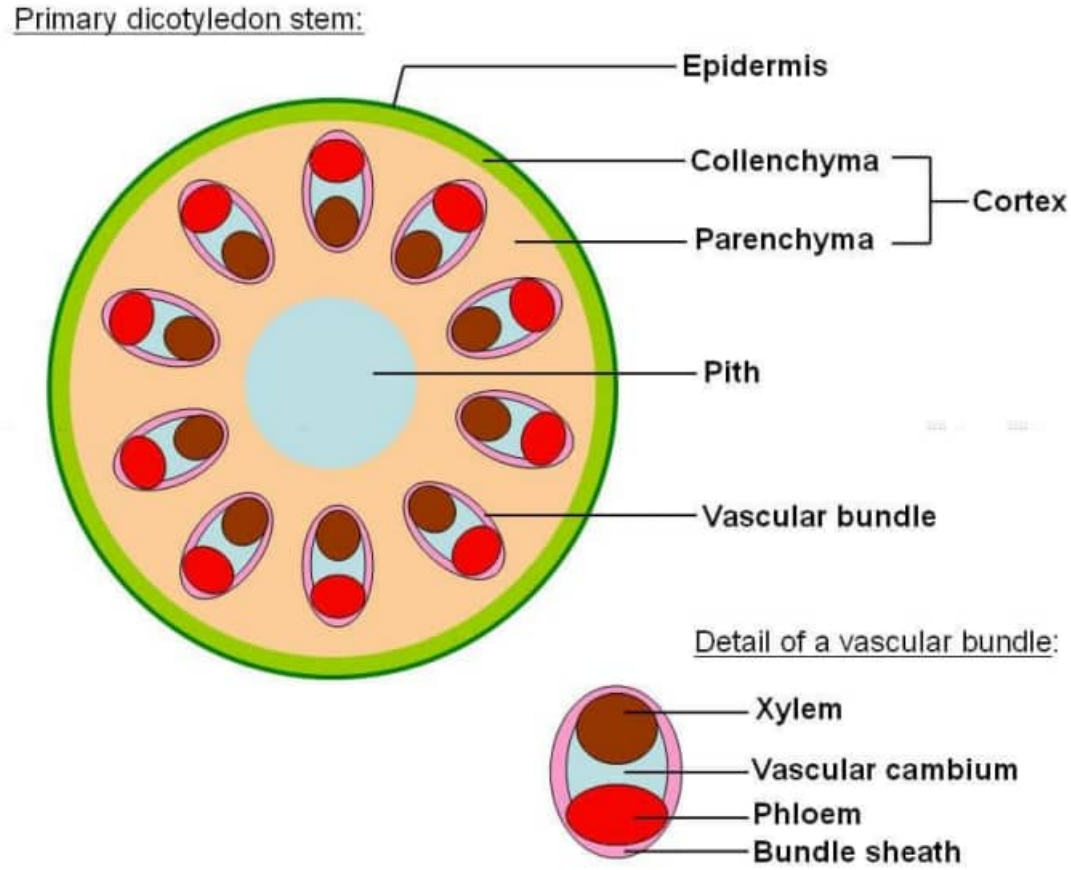
(a) Sieve tubes / sieve elements

(b) Companion cells

(c) Phloem fibres

(d) Phloem Parenchyma

The sieve tube conducts manufactured food from the leaves to other parts of the plant.



Cross section of a dicot system

Mechanism of Transport in Plants

1. Transports of Mineral Salt and Water

i. Osmosis is involved in the absorption of mineral salts and water, it occurs in the zone of the root hairs. Water moves from the root hairs to the xylem cells in the vascular bundles.

ii. Active Transport: The absorption of mineral salts into the root hairs is by active transport. The concentration of mineral salts in the soil water is lower than that of the cells sap of the root hairs thereby facilitating the movement into the root hairs. Mineral salts and ions are absorbed against a concentration gradient. Energy needed for this process is provided by cellular respiration.

iii. Transpiration Pull: It is responsible for dragging water at the leaf end, the pull is transmitted down to the root through a column of water in the xylem elements

The suction force due to transpiration is known as transpiration pull. It is the main force behind the uptake of water and mineral salts up the plants. As water evaporates from the leaves, water is pulled up the Xylem vessels.

2. Transport of Manufactured Food

Manufactured food such as sugar lipids, amino acids is transported through the phloem. The mechanism of transport is believed to be through cytoplasmic streaming.

Sugar e.g. sucrose, amino acids, and other organic molecules enter the sieve elements of the phloem through the plasmodesmata (fine strands of cytoplasm connecting them to adjacent companion cells. The process called **translocation**, or movement of sugar.

The food molecules are transported up or down once within the sieve elements. Translocation of food through the phloem is dependent on the metabolic activity of the phloem cells

EXPERIMENT TO DEMONSTRATE THE FLOW OF MATERIALS IN PLANTS

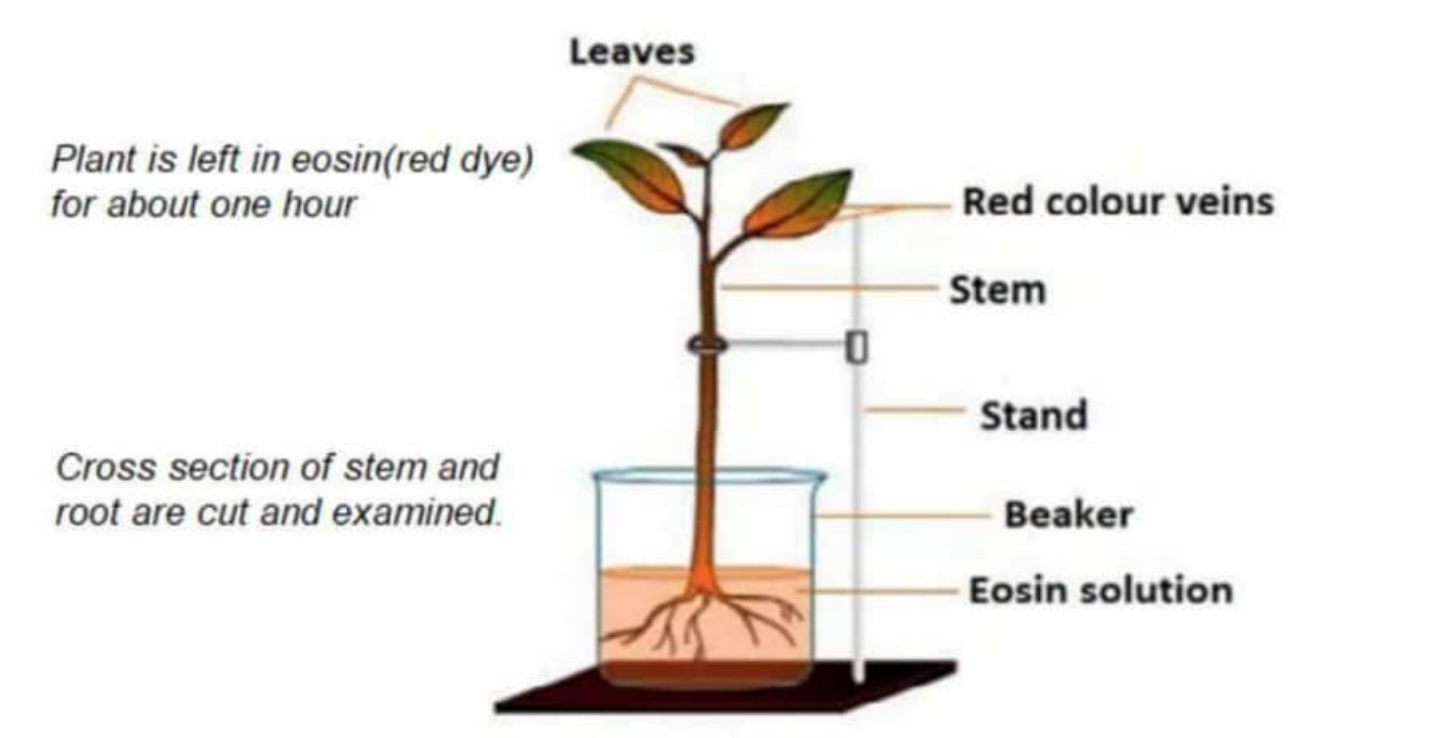
Experiment to Determine the Tissue that Conducts Water in Plants

Materials required: young waterleaf plant, eosin solution (red ink), microscope or hand lens, bleaker.

Method:

Uproot a young waterleaf or balsam plant carefully to avoid damage to the roots, wash off the soil. Place the shoots of the plant in a beaker containing eosin solution for some hours.

Remove the shoots from the solution make a cross section of the root and the stem.



Observation: The eosin has stained some parts of the roots and the stem. The part stained in both the roots and the stem is the xylem.

Conclusion: Xylem vessels are responsible for the transport of materials / water in plant.

Transport of water in plants is driven by the following processes, root pressure, suction pressure, and capillary action (i.e. attraction between water molecules and the walls of the xylem) & transpiration pull.

Experiment to show that Translocation of Food takes place through the Phloem (Ringing Experiment)

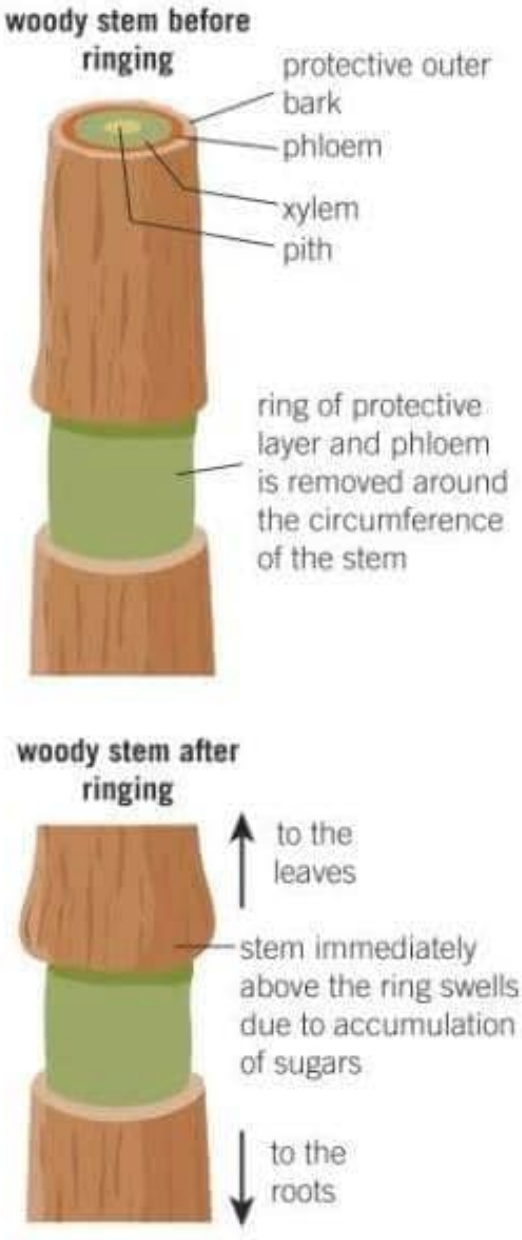
Materials required

Two plants marked A and B and knife

Method

Use a sharp knife to remove the back of a tree marked A. The other tree marked B is the control.

Observe the trees for about 5 weeks



Observation:

i. A swelling is observed at the back of the tree along the ring in plant A but no swelling in plant B

ii. The swelling is as a result of the accumulation of food substance from the leaves through the phloem.

Conclusion: Manufactured food is translocated through the phloem.

RESPIRATORY SYSTEMS

Respiratory Systems and Mechanisms

Respiration describes the metabolic process in cells that breakdown food molecules (glucose) and releases energy for metabolism.

Respiration is a two-stage process called external respiration and internal respiration. External respiration involves the exchange of gases between the organism and its environment while internal respiration also known as cellular respiration or tissue respiration is the oxidation of food substances (glucose) to release energy. It is an enzyme-controlled process.

External respiration is mainly by diffusion of gases across the body surface of small and simple plants and in animals, respiration occurs on the body surface, buccal cavity, lungs etc.

Types of respiratory organelles and organs

Respiratory Organelle	**Organism found**
Body surface	Protozoans, Hydra, flatworms, earthworms
Tracheal system	Insects
Lung books	Spiders
Gills	Fishes
Lungs	Toads, Birds, Mammals
Mouth	Toad

Types of Respiratory Surface

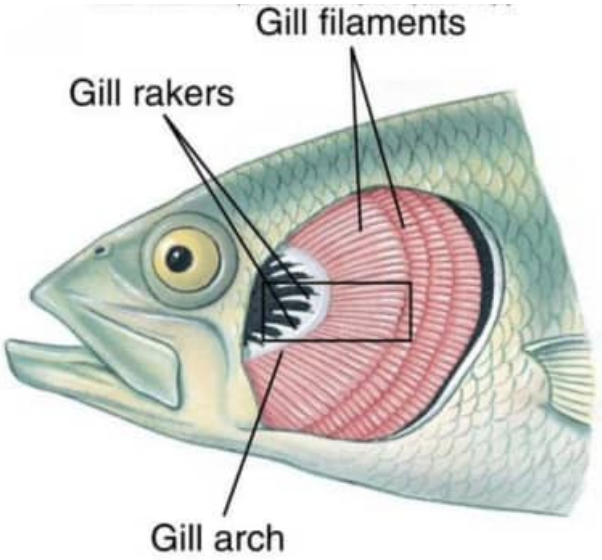
The respiratory Surface is a special area that is developed in order to satisfy the requirements for gaseous exchange in larger organisms. Examples include external gills, internal gills, lungs, and the insect tracheae.

Body surface

1. **Cell membrane:** In simple unicellular organisms such as Amoeba, Paramecium, the cell is close to the external environment. These organisms are small, their surface area to volume ratio is large, literally, gaseous exchange occurs by diffusion across the surface membrane. These organisms do not have specialized structures for gaseous exchange to meet their oxygen demand.

2. **Cutaneous respiration:** It is a form of respiration in which gaseous exchange occurs through the skin of some animals such as earthworms, frogs, toads. In these organisms, the surface area to volume ratio is large. In these organisms, their skin is kept moist so that oxygen or carbon-dioxide can easily dissolve in the moisture before it diffuses across the body surface which is richly supplied with blood vessels so that dissolved oxygen diffuses easily into the blood and are transported to all parts of the body.

Gills



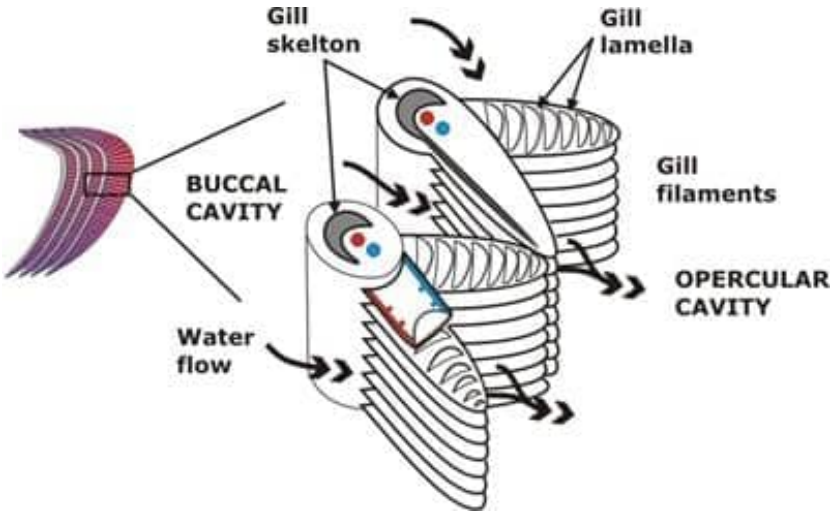
A gill is a respiratory organ found in many aquatic organisms such as fishes, crustaceans, and amphibians which extracts dissolved oxygen from water and excretes carbon dioxide.

In a bony fish, the gills are found inside the gill chambers and protected by the gill cover or operculum.

Each gill consists of a bony framework known as the gill arch, with two rows of numerous filaments attached. These filaments are highly vascularized (i.e richly supplied with blood vessels). Gaseous exchange occurs in the filaments.

Attached to the gill arch are short bony structures known as gill rakers. They serve as filters and protect the delicate gills.

Each gill filament has several flattened plates which increase its surface area for gaseous exchange, these flattened plates are called lamella.



Tracheal System

Insects and some other invertebrates exchange gases between their tissues and the air by the system of air-filled tubes called tracheae. The tracheae open to the outside through tiny holes called spiracles. Air enters and exits the insects via small openings called spiracles which are found in pairs at every segment of the insect's body.

The spiracles are guarded by valves controlled by muscles which enable the insect to open and close them.

The spiracles open into a network of tubes all over the body.

These are tracheae which branches further into tracheoles which comes in contact with the surface of cells in the body of the insects.

Lungs

The lungs are the organs for gaseous exchange in all mammals, birds, most reptiles and some amphibians.

The lungs are located in the thoracic or chest region of the body and consists of air sac's or alveoli which provides a large surface area for gaseous exchange. The lungs are pinky spongy tissues enclosed within a pleural sac that contains pleural fluid which allows the inner and other walls to slide over each other whilst breathing takes place without much friction.

The pleural sac divides the lungs into sections called lobes. The left lung has two lobes while the right has 3(three) strong muscles attached to the rib cage allows expansion and contraction resulting in inflation and deflation of the lungs.

The epithelium of lungs is highly vascularized

Characteristics of an Efficient Respiratory Surface

i. **Thin walls:** Thin walls help to shorten the distance through which gases diffuse. Diffusion is relatively slow, so a thin surface will increase the rate of diffusion

ii. **Large surface area:** This further increases the rate of gaseous exchange

iii. **Moist Surface:** Gases dissolve in the moisture helping them to pass across the gas exchange surface. The Oxygen dissolves before entering the blood or body fluid

iv. Permeable walls allows gases to pass through freely

v. **Extensive blood supply:** respiratory surfaces are richly supplied with blood capillaries which ensures oxygen-rich blood is taken away from the respiratory surface to the tissues

RESPIRATORY SYSTEM OF MAN

Respiratory System of Man

The respiratory systems of mammals consist of the following parts: nose or nostrils, pharynx, larynx, trachea, bronchi, lungs.

1. **Nose**: The nose consists of two air passages called the nostrils. The lining of the nostrils secretes mucus which keeps them moist. Also present in the nostrils are hairs that help to filter air entering the nose

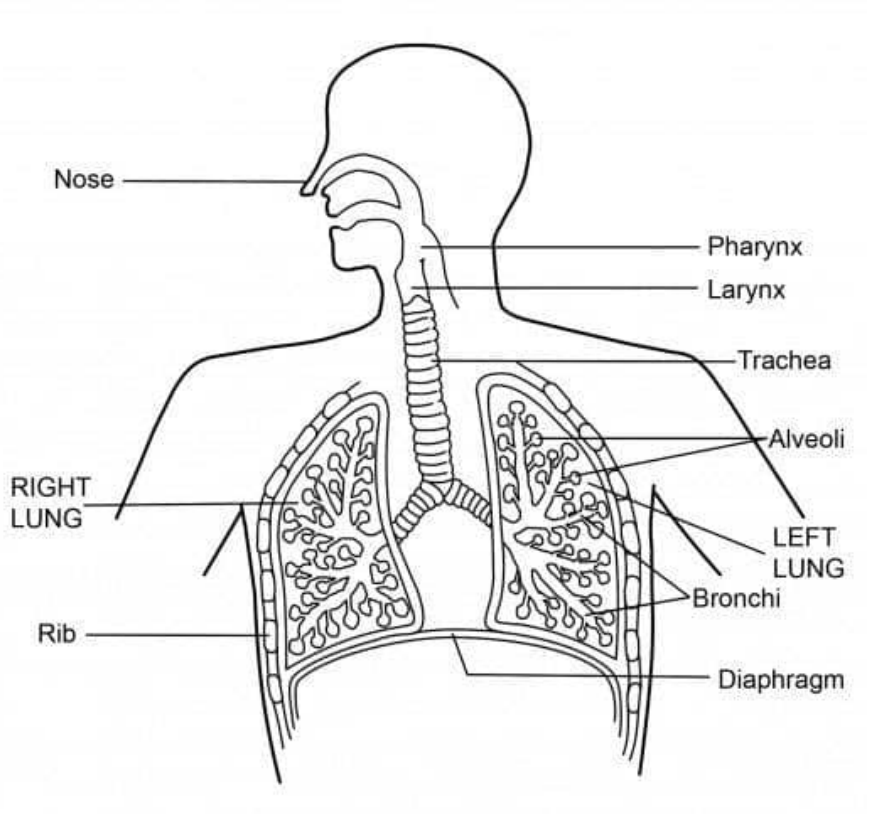
2. **Pharynx**: The nostrils lead into the posterior part of the mouth cavity called the pharynx. The pharynx leads into the gullet (oesophagus) and larynx (voice box). Food goes into the gullet while air into the trachea. The epiglottis directs food into the gullet.

The upper part of the trachea is known as the glottis. The epiglottis closes the glottis when food is swallowed to prevent food from entering the trachea.

3. **Larynx** (voice box) The larynx is made of cartilage to prevent it from collapsing, It leads into the trachea. The membrane lining the inner surface of the trachea secretes mucus that keeps the surface moist as well as traps dust particles inhaled air.

4. **The trachea**: The trachea is made up of cartilage which prevents it from collapsing. It is about 10cm long in man. It branches into two bronchi (sing /bronchus).

Lungs: The two bronchi enter the lungs. Each lung has many tiny tubes called the bronchioles each terminating in air sacs called alveolus which is supplied with many blood capillaries.



The human respiratory system

Mechanism of Breathing in Man

Inspiration / Inhalation

When we breathe in the following events occurs

1. The pillar muscles of the diaphragm contract thereby flattening the diaphragm i.e it changes from a dome shape to a flat shape. The volume of the chest cavity increase
2. At the same time the external intercostal muscles contract while the internal intercostal muscles relax.
3. The ribs are pulled upward and forward
4. The thoracic cavity enlarges thereby decreasing the pressure of air in the lungs. The lungs expand also.
5. The walls of the lungs are pulled out and air rushes in through the trachea to the bronchi and then the bronchioles. Air that flows into the lungs through the nostrils is warm, moist, and free from dirty and other impurities.

Expiration / Exhalation

1. When we breathe out the pillar muscles of the diaphragm relax thereby causing the diaphragm to return to its original dome shape.
2. At the same time, the volume of the chest cavity decreases as a result of the contraction of the expiratory internal intercostal muscle and relaxation of the external intercostal muscle.
3. The ribs move downwards and backwards.
4. The air pressure in the lungs increases above the atmospheric pressure forcing air to flow out of the lungs through the trachea

Composition of inspired and expired air

Components	**Inhaled air (%)**	**Exhaled air (%)**
Oxygen	21.0%	16.0
Nitrogen	79.0	79.0
Carbon-dioxide	0.03	4.00
Water vapour	variable	variable

NB: During exhalation, air in the lungs is not expelled totally. The air left is known as the residual air. The air that is exchanged with each breath is known as the tidal air.

Gaseous Exchange in the Lungs

The alveoli in the lungs are in contact with blood capillaries. The oxygen in the alveoli diffuses through the thin walls of alveoli into the blood in the capillaries while carbon dioxide diffuses out from the blood into the alveoli and is forced out through the trachea.

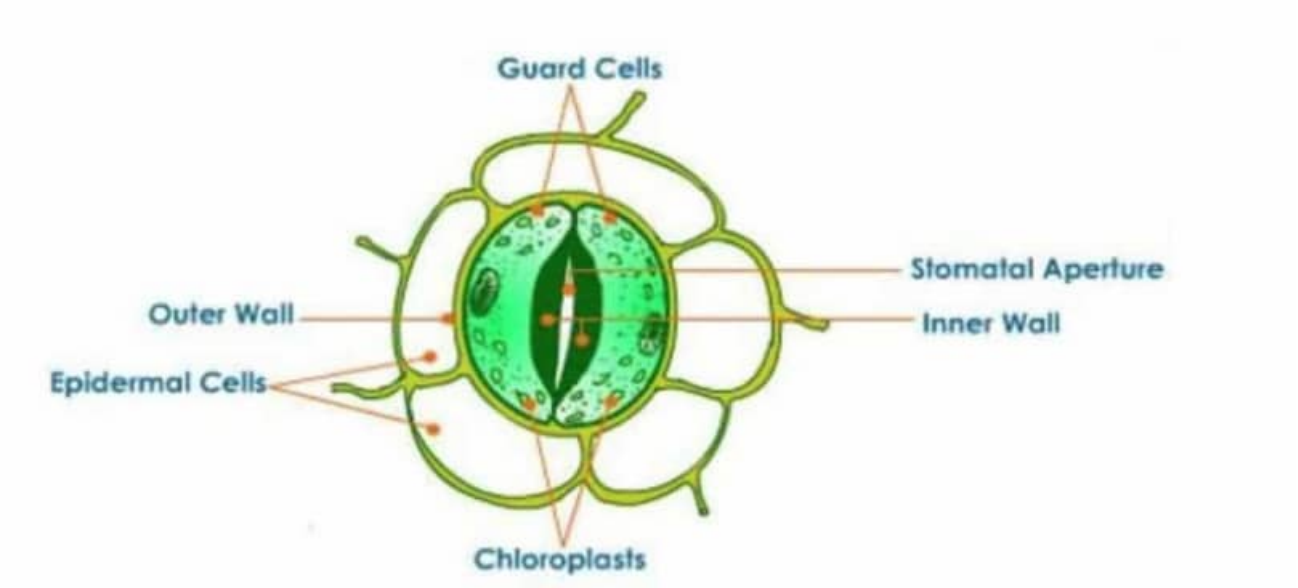
MECHANISM OF GASEOUS EXCHANGE IN PLANTS

Mechanism of Gaseous Exchange in Plants

Plants do not have a specialized respiratory organ. Gaseous exchange in plants occurs through the stomata in the leaves, and lenticels in the stems

Structure of the Stomata

1. The stomata are found in the epidermis of the leaves. They are more abundant at the lower epidermis.
2. Each stomata consists of minute pores called stoma, surrounded by a pair of guard cells
3. The cell wall surrounding the stoma is tough, flexible and thin.
4. In the epidermis of the leaves, only the guard cells are able to photosynthesis because of the presence of chloroplast in them.



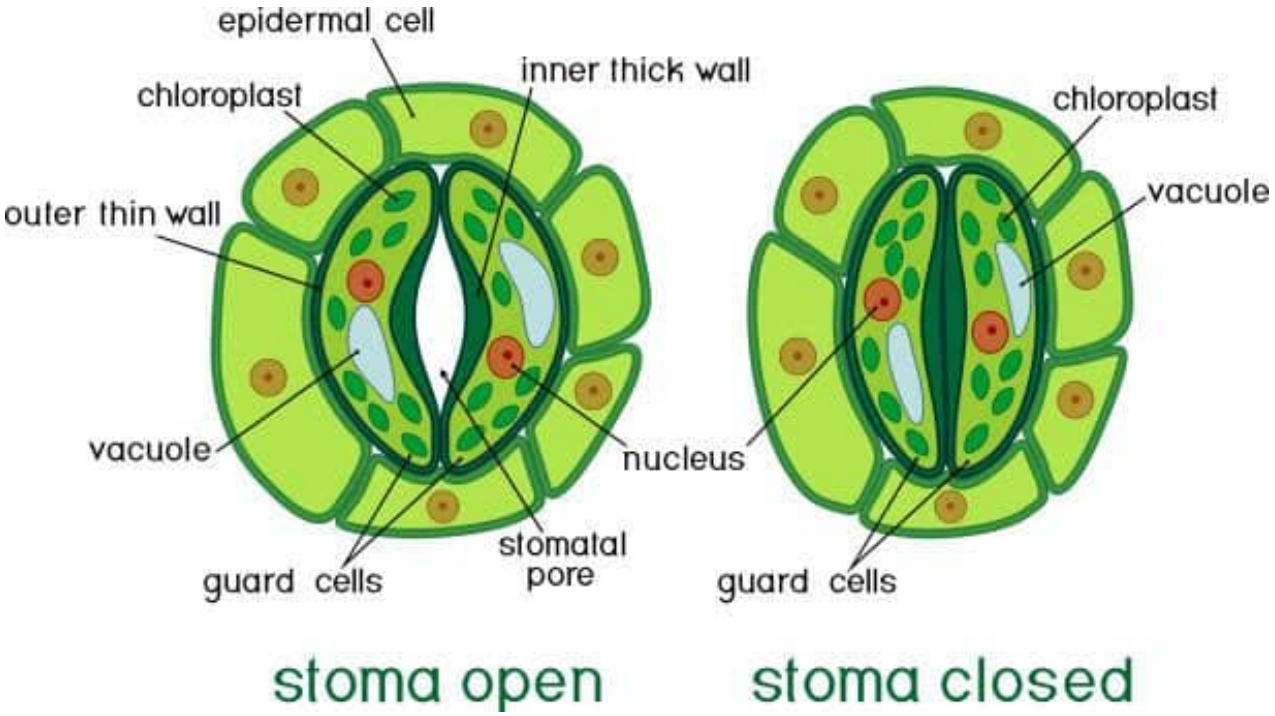
Stomata

Mechanism of Gaseous Exchange of Gases Through the Stomata of Plants

In plants almost every part respires, oxygen from the atmosphere diffuses in through the stomata in the leaves. Oxygen enters the stomata by the process of diffusion and into other cells of the leaves. The oxygen is utilized in the breakdown of glucose.

The mechanism of the opening and closing of the stomata depends on turgor pressure in the guard cells. In the daytime, the guard cells contain starch manufactured by the chloroplast during photosynthesis. The sugar produced is soluble and increases the concentration of the sap of the guard cells. Water flows from neighbouring cells into them by osmosis causing them to become turgid. The stomata remain open. In the night, sugar in the guard cells is converted to starch which is insoluble. The cell sap in the guard cells remains at a lower concentration than those of the neighbouring cell.

Water moves out of the guard cells by osmosis causing it to become flaccid. The stomata then closes.



EXCRETORY SYSTEMS I

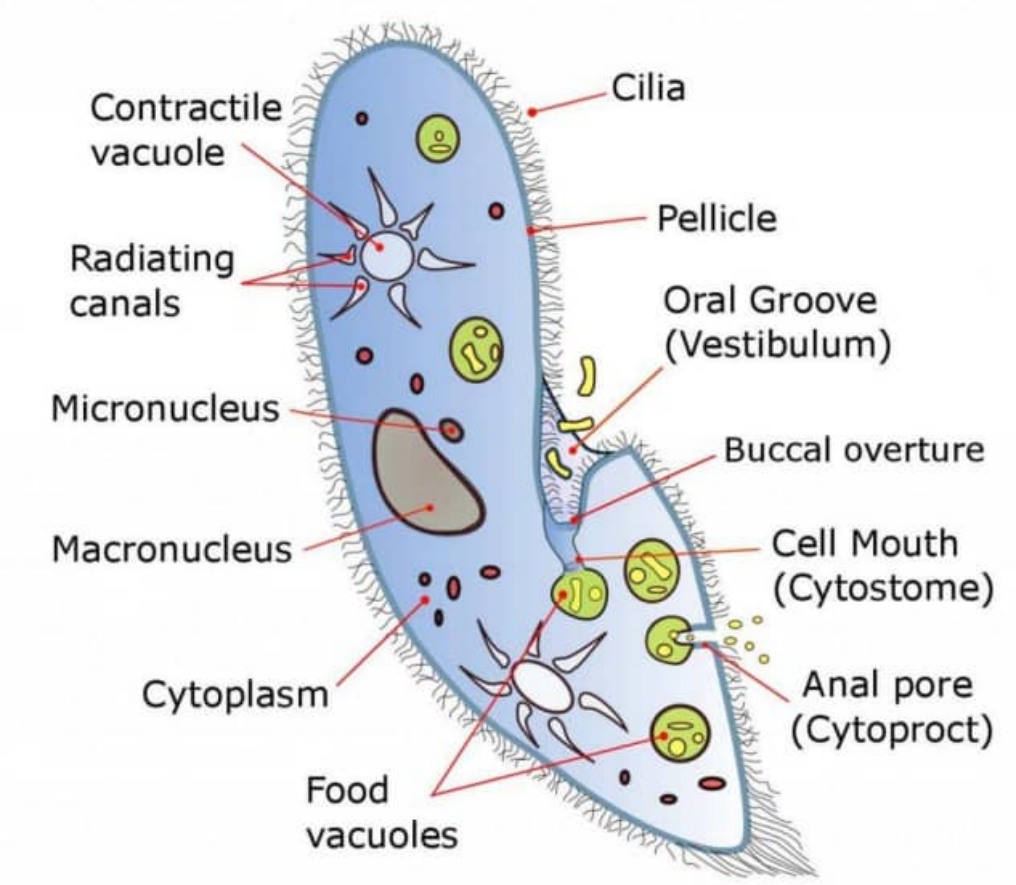
Excretory Systems

Excretion is the removal of waste products of metabolism from the body of an organism. These waste products include nitrogenous compounds such as ammonia, and excess salts, carbon-dioxide and water. They are of no use to the body and if allowed to accumulate may become poisonous to the cells. The excretory systems include Malphigian tubules, kidney, stomata, lenticels and stomata in plants.

Excretory Mechanisms in Protozoans

Contractile Vacuole

Contractile vacuole occurs in many freshwater protozoans and sponges. It is a membrane-surrounded vacuole that periodically expands, filling with water, and then suddenly contracts, expelling its content to the exterior of the cell. It removes excess water which continually enters the cell by osmosis from the environment or with food. The contractile vacuole is concerned with osmoregulation and excretion. Examples of organisms that uses contractile vacuole for excretion and osmoregulation are Amoeba, Paramecium, Euglena, etc.



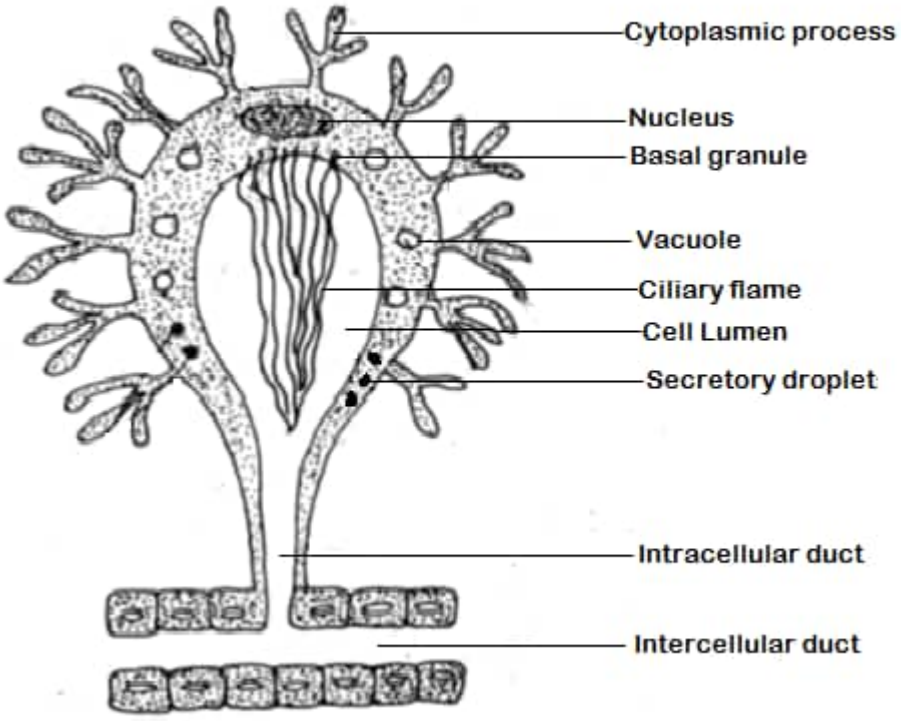
Contractile Vacuole of Paramecium

Excretory System in Platyhelminthes

The flame cell is the excretory system in Platyhelminthes (flatworms) such as *Planaria, Taenia, Schistosoma, Fasciola.*

The flame cells occur in all parts of the body. They are usually connected together by canals which ultimately open to the exterior of the animal. Each flame cell has a number of cytoplasmic processes, a large intracellular cavity and a bundle of flagella which appears like a candle flame.

Waste materials from the interstitial fluid such as ammonia and carbon dioxide move into the flame cells. These are moved by the flagella outwards through the excretory ducts.



Flame Cell

Excretory System in Earthworms

Nephridia are the excretory tubules in Earthworm. They function like the kidneys in mammals.

A nephridium has a ciliated funnel known as the nephrostome, which opens into a long coiled tube and a coelomic cavity.

The muscular tube opens to the outside on the ventral side of the worm in the next segment through the nephridiopore.

As waste fluid flows through the long tube, substances such as sugar, water, salt needed by the organism are reabsorbed through the tube into coelomic fluid.

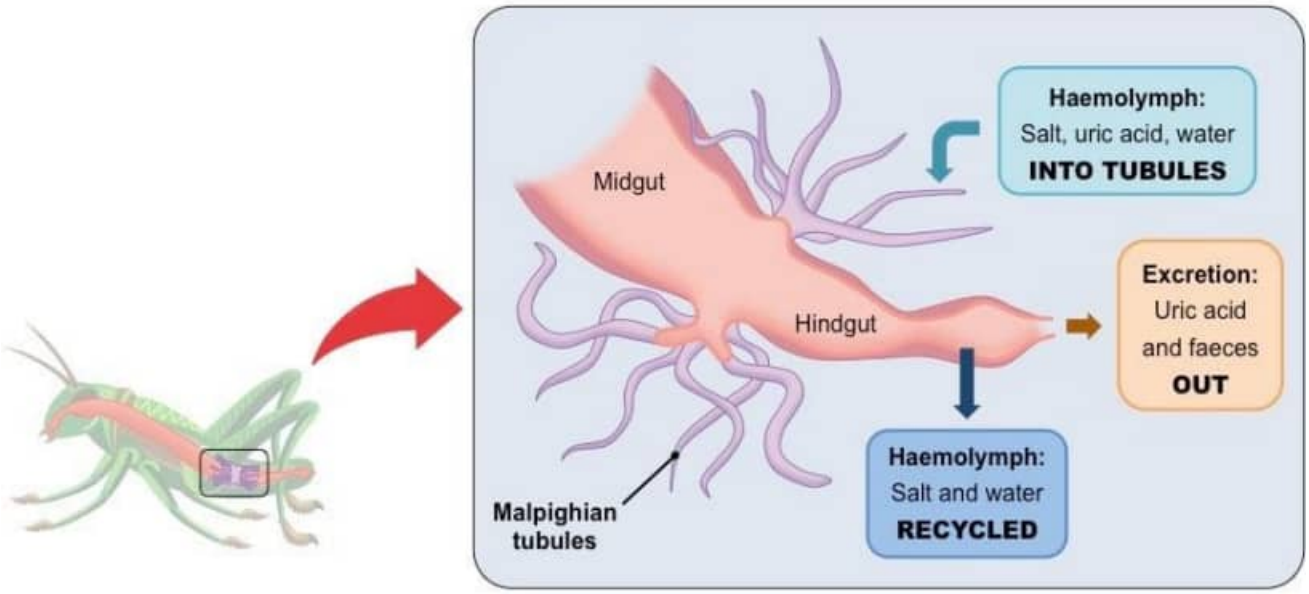
Excretory substances pass out through the nephridiopore to the outside.

Excretory System in Insects

The excretory system in insects is made up of the Malphigian tubules, which extend from the alimentary canal, located between the midgut and the hindgut.

The malpighian tubules are outgrowths from the digestive system. The tubules are bathed with blood in the haemocoel. Waste materials diffuse into the malpighian tubules from their blood, water and bicarbonates are reabsorbed along the tubules.

As water is reabsorbed, the nitrogenous wastes are precipitated to form Uric acid which is passed out with the feaces.



Excretion in Insects

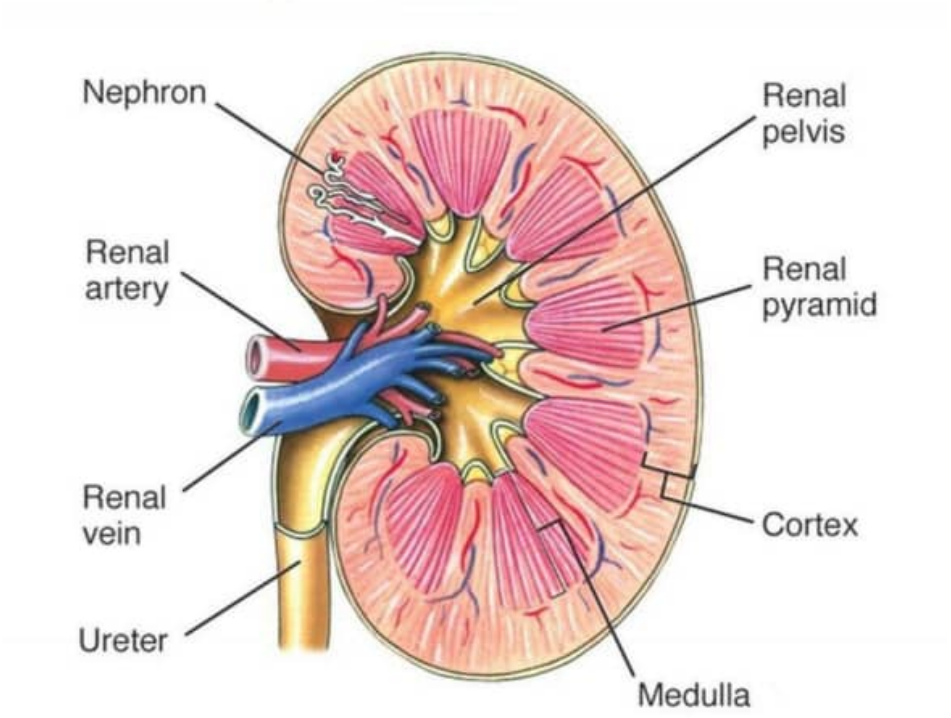
EXCRETORY SYSTEMS II

Excretory System in Mammals

The major organs of the excretory system in mammals are the kidneys. There are two reddish-brown, bean-shaped kidneys located on either side of the abdominal walls. The kidneys are supplied blood by the renal artery while blood from the kidneys is drained into the renal vein which empties into the inferior vena cava. The kidney is connected to the urinary bladder by the ureter which arises from hilium.

A longitudinal section of the kidney shows that it has two distinct layers, an outer cortex and an inner medulla. Each kidney contains millions of urinary tubules or (nephron) which is supplied with a network of blood capillaries.

The nephron is the functional unit of each kidney. It consists of the Bowman's capsule and a network of blood capillaries called glomerulus which fits into the Bowman's capsule, distal and proximal convoluted tubules, loop of Henle, and the collecting duct.



Drawing of the Left-side of the kidney

The function of the Kidney

The kidneys perform the function of excretion in two phases

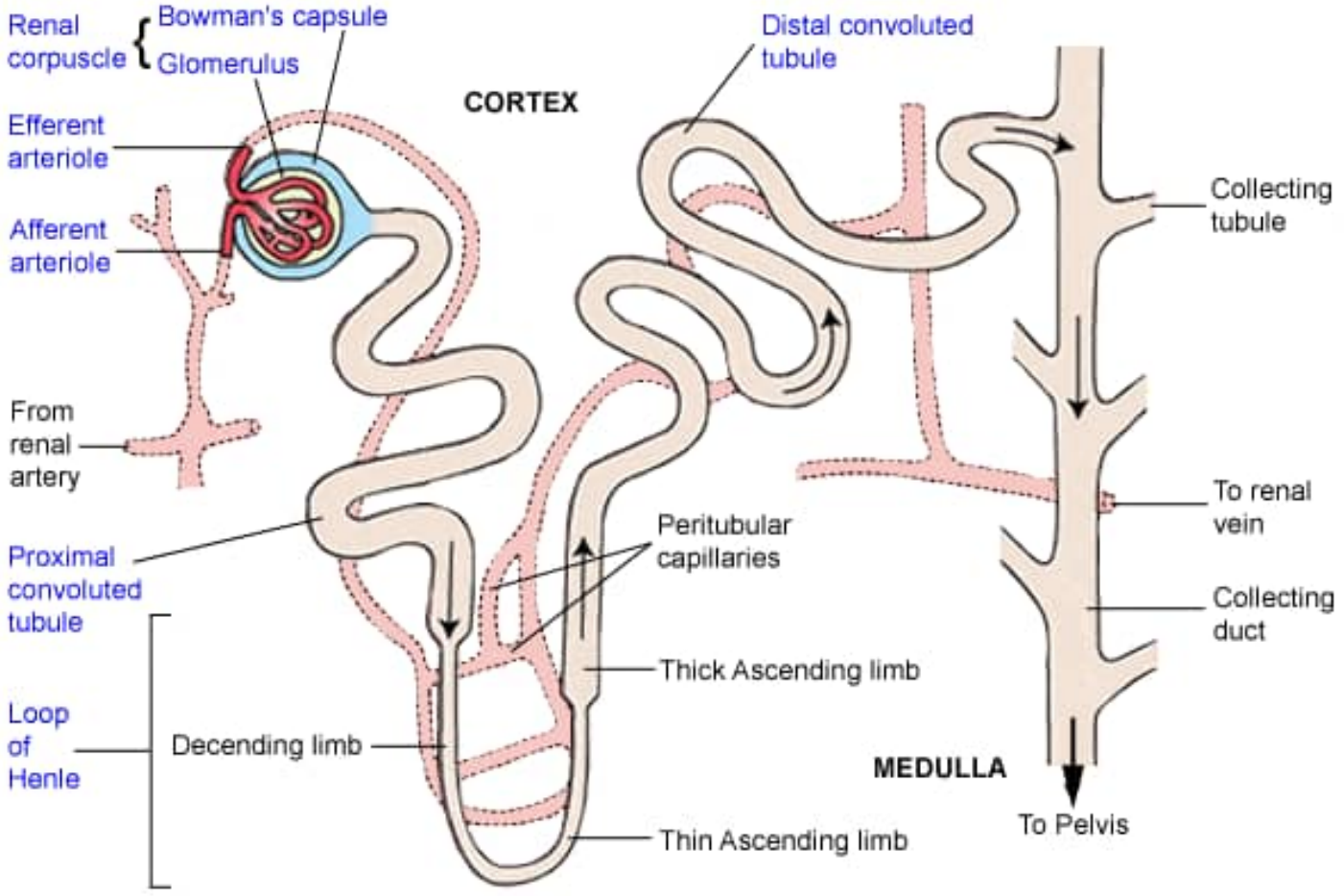
(i) Ultrafiltration

(ii) Selective reabsorption

Ultrafiltration

Blood containing wastes products enters the kidney from the renal artery. The blood passes into the glomeruli in the Bowman's capsule.

In each glomeruli, ultrafiltration occurs due to the high hydrostatic pressure in the glomeruli. The liquid that enters the Bowman's capsule is the glomerular filtrate.



The urinary tubule or nephron

Selective Reabsorption

As the glomerular filtrate containing absorbed food substances such as glucose, water, salts, urea, and excretory wastes flows through the convoluted tubules, substances that are useful are selectively reabsorbed. Glucose are amino acids, vitamins and water reabsorbed at the proximal convoluted tubule into the blood vessels, and consequently, this creates an osmotic pressure that causes water to be reabsorbed by osmosis.

Salts are absorbed into the medulla by active transport at the loop of henle, water is also reabsorbed at the loop of Henle. At the distal convoluted tubule, the absorption of water molecules will depend on the nature of the filtrate, whether hypotonic or isotonic.

If isotonic, there will be no net movement of water molecules. But if it is hypotonic to the blood, more water is reabsorbed.

The filtrate at this stage becomes a solution of urea and waste products(urine).
The urine in conveyed to the collecting duct via the ureter.
Urine is temporarily stored in the urinary bladder before elimination.

Excretory System in Plants

Plants as living organisms produced metabolic wastes such as carbon dioxide, water, oxygen. These metabolic wastes can be retained and recycled in plants. The by-products of respiration i.e carbon dioxide and water are retained and used for photosynthesis. Oxygen a by-product of photosynthesis is used by the plant for respiration.

Plants generally, do not have an excretory organ, the metabolic wastes are excreted by parts of the plants such as leaves, fruits, barks, flowers by storing them in the parts and shedding them eventually. Excretory products of plants include carbon-dioxide, oxygen, water, and other substances that are often classified as wastes such as

1. Tannins
2. Alkaloids, mucilage, crystals, gum, resins
3. Anthocyanin

Alkaloids, mucilage, gum are converted into insoluble forms and deposited as oil droplets or granules either in the cell sap or parts of the plants like leaves, barks, etc. which are shed from the plants. Some of the waste products may be of economic importance to man e.g.
Alkaloids such as morphine and quinine are used as medicine.
Latex, resins, gums are used as industrial raw materials.

Anthocyanins are a type of flavonoid, a class of compounds with antioxidant effects. Found naturally in a number of foods, anthocyanins are the pigments that are responsible for most red to purple colors in plants.

Purple cauliflower contains anthocyanins

NUTRIENT CYCLING IN NATURE I

Nutrient Cycling in Nature

Nutrient cycling is one of the most important processes that occur in an ecological system. It refers to the movement and exchange of nutrients between living organisms and the non-living parts of the environment. It occurs as plants and animals consume nutrients present in the soil, these nutrients are released back into the environments through deaths and decomposition.

Carbon Cycle

The various processes by which carbon is removed and returned to the environment is referred to as carbon cycle.

A. Processes that removes carbon from the Atmosphere

Carbon is removed from the atmosphere in form of carbon- dioxide through.

(i) **Photosynthesis:** During photosynthesis, green plants absorb carbon dioxide from the atmosphere and use it to manufacture carbohydrates.

(ii) Where animals feed on green plants the carbon compounds become part of the bodies of these animals

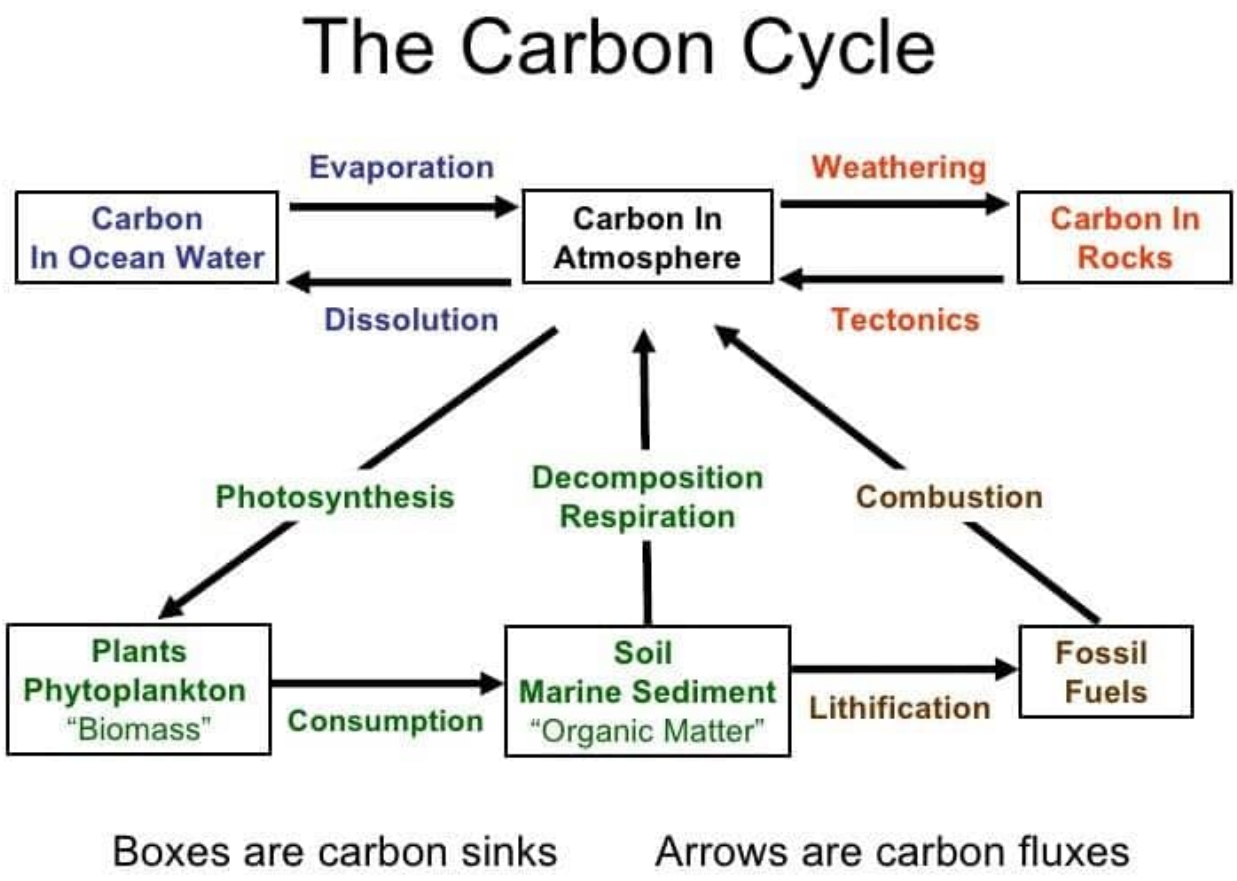
(iii) The carbon compounds are preserved in form of coals, natural gas and oil

B. Processes that release carbon (in form of CO_2) into the Atmosphere

(i) **Combustion or burning:** Burning of compounds such as wood, fossil fuels e.g natural gas, coal, etc. Releases carbon dioxide into the atmosphere

(ii) **Respiration:** During respiration, carbon compounds such as glucose are broken down or oxidized to carbon dioxide and water

(iii) **Decomposition:** When plants and animals die, they decompose or decay. This process is facilitated by decomposers such as fungi and bacteria. Carbon-dioxide is released during the process. Some inorganic compounds released are absorbed by the decomposers. During respiration the decomposers also release carbon-dioxide.



Importance of Carbon Cycle

1. Ensure the amount of carbon dioxide in the atmosphere is relatively constant (about 0.03%)
2. It provides the plant with carbon-dioxide for photosynthesis
3. Carbon compounds are transferred from one organism to another in the food chain
4. The carbon cycle ensures the continuous flow of carbon compounds between living organisms and the environment.

Oxygen Cycle

The process by which oxygen is removed and returned to the atmosphere is referred to as oxygen cycle.

Process that remove oxygen from the atmosphere

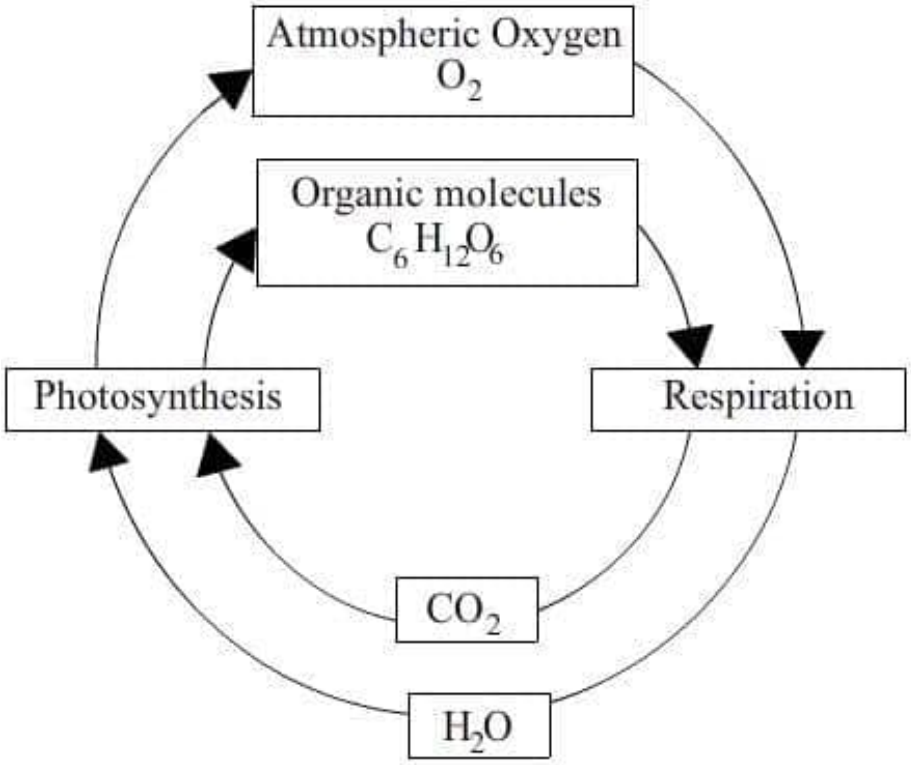
(i) Cellular respiration: During respiration living things breathe in oxygen.

(ii) Combustion or burning of material e.g. fossil fuels, natural gas.

(iii) Decomposition or decay

Process that release oxygen into the atmosphere

(i) Photosynthesis



Oxygen Cycle

Importance of Oxygen Cycling

Oxygen is required by plants and animals for cellular respiration. The oxygen cycle ensures that the amount of oxygen in the atmosphere is constant.

Carbon – Oxygen Balance

The percentage of oxygen in the atmosphere is 21% while carbon – dioxide is about 0.03%. The process of respiration and photosynthesis ensures that the percentage of oxygen and carbon is relatively constant in the environment.

However, increased human activities have led to an increased amount of carbon dioxide in the atmosphere. The amounts of carbon-dioxide are increased due to deforestation and the burning of fossil fuels. This could affect the carbon-oxygen balance. The increased amount of carbon-dioxide levels will result in elevated global temperatures.

NUTRIENT CYCLING IN NATURE II

Water Cycle

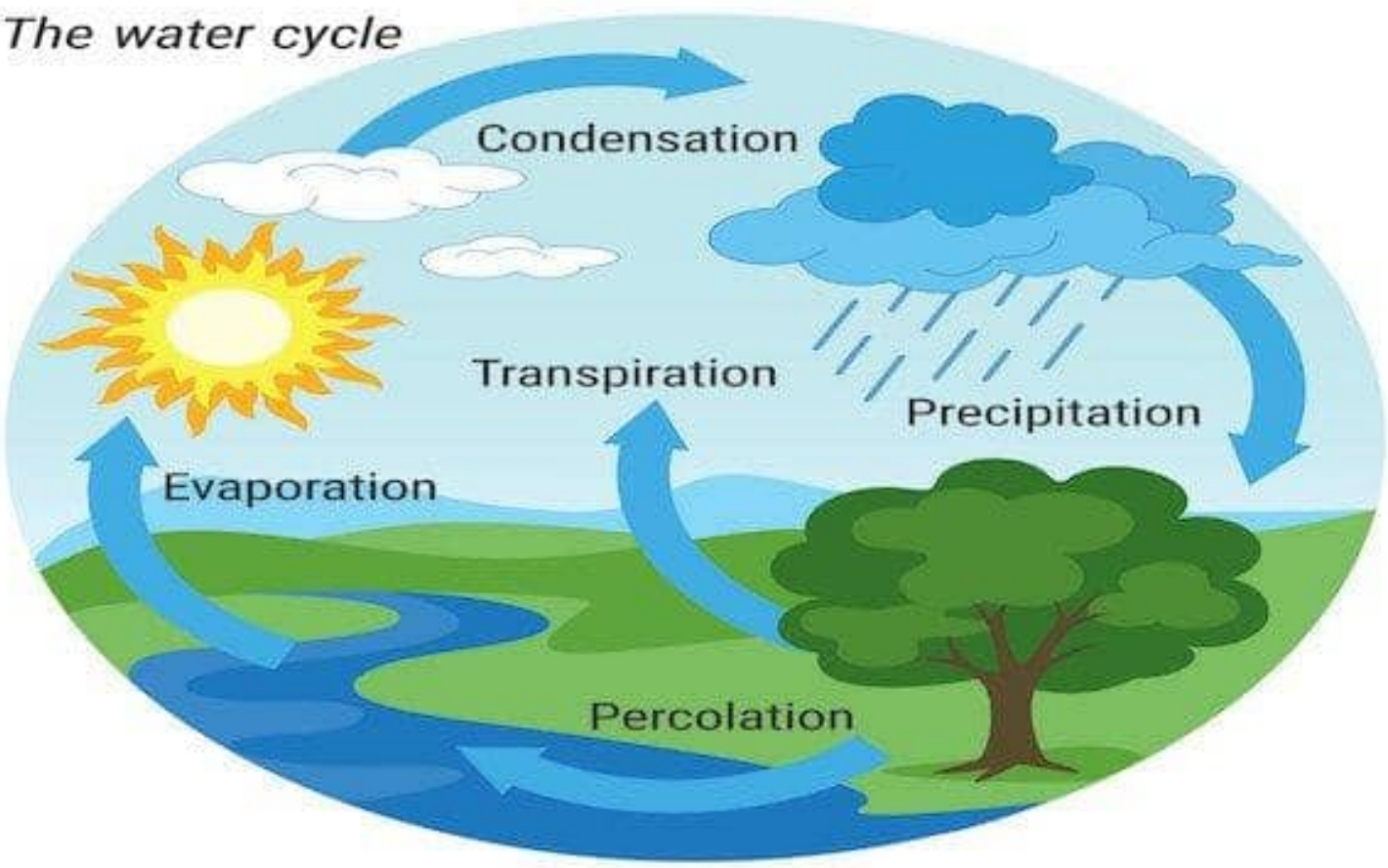
The various processes by which water moves through the water bodies, atmosphere, and land are referred to as the water cycle.

Process of Water Cycle

1. **Evaporation:** It occurs when there is sufficient energy. It is the process whereby water evaporates from the exposed soil surface.
2. **Respiration:** Water is also lost to the atmosphere during respiration
3. **Transpiration:** Plants lose water to the atmosphere through the leaves by transpiration
3. **Precipitation:** As water is lost through evaporation; respiration, and transpiration into the atmosphere, it cools and condenses into water droplets which fall back to the earth as precipitation in form of rain or snow. Some of the rain falls into water bodies.

Parts of the rain enter tiny spaces in the soil. The process is known as **percolation**.

4. **Runoff:** When water accumulates above impermeable rock layer, it forms groundwater. Unabsorbed water flows over the land surface into rivers, streams, and ponds. As evaporation occurs, the cycle is repeated again.



Water-Cycle

Importance of Water to Living Organisms

1. Water is a medium for the transport and absorption of nutrients in plants
2. It is a medium in which many chemical reactions occur, such as excretion
3. Water provides support and rigidity to plants
4. is required for the diffusion of materials across surfaces
5. It helps to remove excess heat through sweat, heat, and transpiration
6. Water is the main component of

(i) Protoplasm

(ii) Blood plasma

7. Water acts as a solvent for soluble food substances in digestion of food

Nitrogen Cycle

Nitrogen cycle consists of complex processes through which nitrogen is naturally added or removed from the soil atmosphere

Processes that removes Nitrogen from the Atmosphere

Nitrogen is lost from the soil through

(i) Absorption in plants

(ii) Leaching

(iii) Denitrification (i.e. the conversion of nitrates to atmospheric nitrogen by denitrifying bacteria.

Processes that return Nitrogen to the Soil

(i) **Putrefaction (decay):** Plant and animal remains in the soil decay or decompose by the action of putrefying bacteria and fungi and are changed to ammonium compounds.

(ii) **Nitrification:** the conversion of ammonia and ammonium compounds to nitrates is known as nitrification. First Ammonia and ammonium compounds are converted to nitrites by *Nitrosomonas* and from nitrites to nitrates by nitrobacteria

(iii) **Nitrogen fixation:** This is the conversion of nitrogen in the air into nitrogenous compounds.

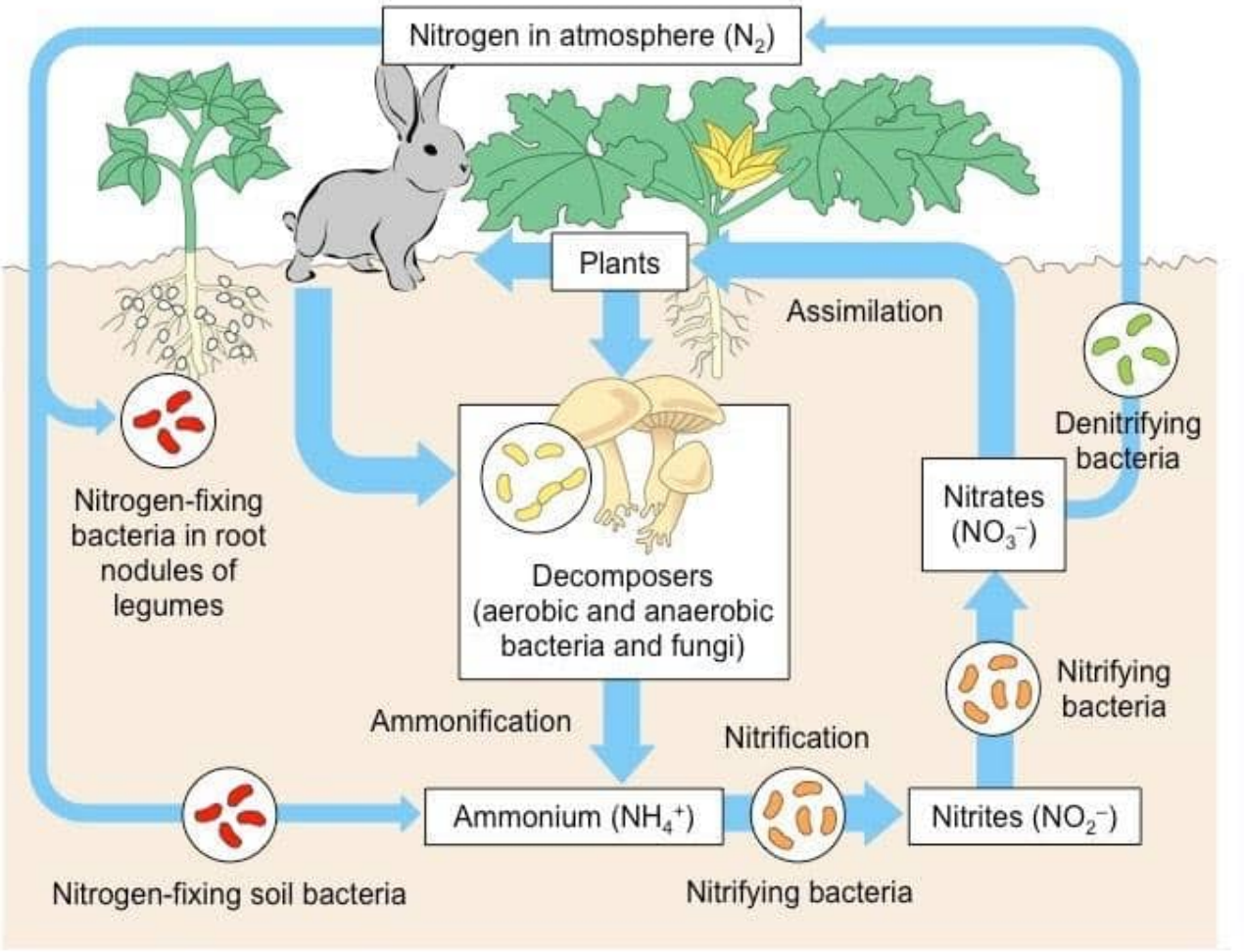
(a) Nitrogen – fixing bacteria

We have two types of nitrogen fixing bacteria; free – living nitrogen fixing bacteria and symbiotic nitrogen fixing bacteria.

Free nitrogen-fixing bacteria e.g Azotobacter are able to convert atmospheric nitrogen into ammonium compounds.

Symbiotic nitrogen-fixing bacteria in the root nodules of leguminous plants are able to fix nitrogen found in the soil to ammonium compounds.

During lightning and thunderstorms – In the presence of lightning, atmospheric nitrogen reacts with oxygen to form oxides of nitrogen which dissolves in rainwater to form mild acids (nitrous and nitric acids). These acids react with other compounds in the soil to form nitrates, very little nitrogen is fixed this way.



Nitrogen Cycle

Importance of Nitrogen Cycle

1. It ensures that the percentage of nitrogen is the atmosphere is relatively constant
2. Ensures nitrates is adequately supplied to plants to make proteins
3. Ensures nitrates is adequately supplied to other living organisms for the synthesis of proteins

ECOLOGICAL MANAGEMENT

Biological Associations

Meaning: The interactions between two or more types of organisms in an ecosystem is known as association, which may be beneficial, harmful, or natural to each of the organism in the association.
Symbiosis is a close association between two or more species of organism. Symbiosis could be in any of these three types of relationship.

i. Parasitism

ii. Mutualism

iii. Commensalism

In these associations, at least one of the organism benefits.

Parasitism

Parasitism is an association in which one organism (parasite) lives on or in the body of another organism (host).
The parasite obtains its nutrients and shelter from its host. Parasites benefits in the association at the expense of their host, while the host suffers.
Examples:

Tapeworm and man

Tapeworm is an intestinal parasite. It derives its nutrients from absorbing dissolved food substances from the intestine of the host (man).
The host suffers as tapeworm feeds on part of the food eaten by man.

Parasitic Plants

An example of a parasitic plant is mistletoe. It is a parasite of a plant. It grows on trees and extends its roots into their branches to absorb nutrients and water with the aid of a specialized structure known as haustoria. Mistletoe contains chlorophyll, it manufactures its food using the water absorbed from the plant.
Mistletoe is a partial parasite total parasites of plants lack chlorophyll and therefore depend entirely on other plants to obtain nutrients e.g Dodder plants.

Parasitism – Mistletoe on Oak Tree

Commensalism

Commensalism is an association between two organisms of different species in which one benefits and the other is not adversely affected.

Examples;

Shark and remora fish:

The remora is a small fish which attaches itself to the shark by means of a sucker to the body of the shark. The shark carries the remora about, when the shark feeds, the remora fish feeds on the scraps of food particles that fall out towards it.

In this association, the shark gains nothing but the remora enjoys protection as well as gets food.

Shark and Remora Fish

Certain bacteria in the gut of man

Certain bacteria live in the large intestine of humans and feeds on small particles of undigested food there. In this association man is not harmed, the bacteria benefit by feeding on the undigested food.

Mutualism

Mutualism is a close association between two organisms of different species which is beneficial to both of them.

Examples of mutualism

i. **Lichen**

Lichen is a close association between a fungus and an alga. An example of lichen is Tribouxia an ascomycete fungi.

The alga species is protected and housed by the fungus. The fungus also absorbs water and mineral salts for the alga. The fungus benefits from the association it feeds on part of the food produced by the alga.

ii. **Protozoa in the alimentary canal of termites**

Termites feed on wood but they do not have the enzyme to digest cellulose present in the wood. In their diet is a protozoa known as *Trichonympha*, which secretes enzymes that can breakdown cellulose for the termites. The protozoa obtain shelter and protection from the termite and also uses cellulose.

iii. **Micro-organism in the intestinal tract of ruminants**.

Herbivores such as cattle, goats, and sheep feed on grasses. They are unable to digest cellulose present in grasses. This is because they do not produce cellulose digesting enzymes. They depend on the bacteria in their gut to secrete cellulose to breakdown/digest cellulose in the grasses/plant for the animals to eat. In return, the bacteria are protected & housed and also have a constant supply of food. Other examples include Rhizobium in the roots of leguminous plants.

ECOLOGICAL TOLERANCE

Ecological Tolerance

Organism are affected by various ecological factors in their environment, such as light, temperature, pH, heat and moisture.

The ability of an organism to withstand unfavourable ecological factors in their habitat is referred to as tolerance.

Tolerance

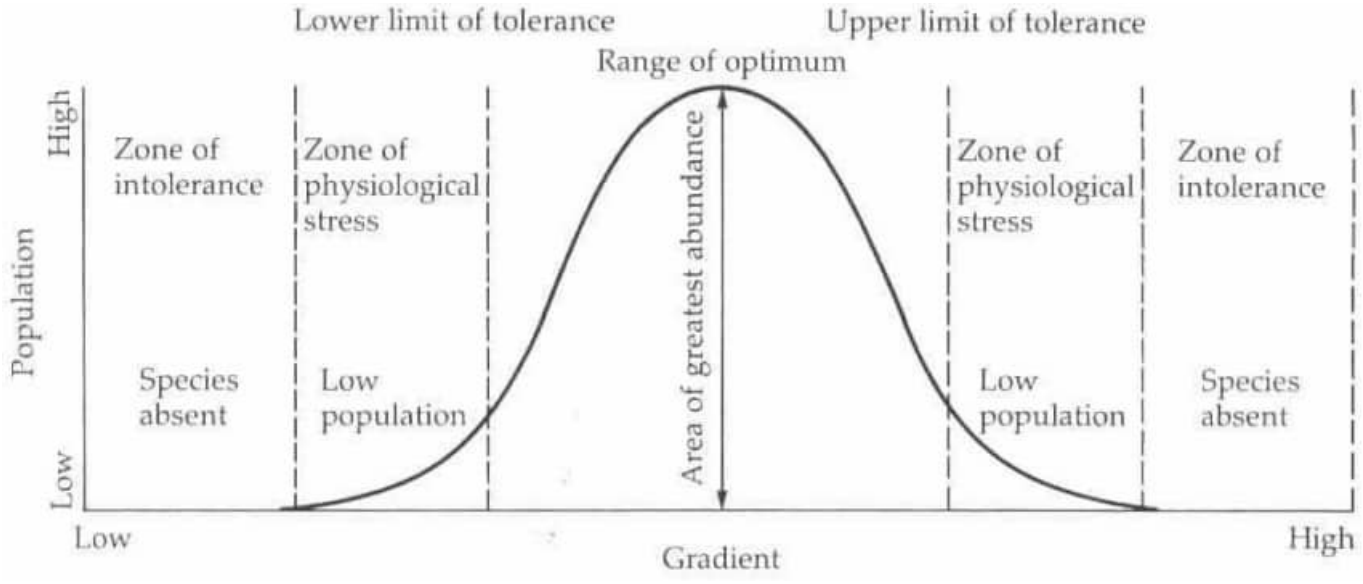
Organisms vary in their ability to survive unfavourable conditions. For each abiotic factor, there is an optimal range to which an organism can tolerate and function effectively, and the range differs between two species of organisms. The tolerance range for an abiotic factor lies between a lower and upper limit. Beyond the range of tolerance, organisms struggle to survive. At this stage, the organisms are said to be under physiological stress. The organism may be eliminated beyond the optimal range.

The lower limit of tolerance to any of the abiotic factors is referred to as the minimum range between minimum and maximum limit. This range is most favourable for optimal growth and reproduction.

Geographical Range

Geographical range refers to the special area where an organism lives naturally. Geographic range is influenced by both biotic and abiotic factors.

The abiotic factors that determine or influence geographic range are air, temperature, and snow depth which are mostly climatic. Biotic factors that affect the geographic range are interactions between species such as predation and competition. Areas between the limits of tolerance i.e. the maximum and the minimum limits enable organisms to grow and reproduce successfully in their habitat.



Graph showing Range of Tolerance

ADAPTATION

Adaptation

Adaptation is features, functions, or behaviour that enable an organism to survive and reproduce successfully in response to changes in the environment.

Forms of Adaptation

1. Structural Adaptation
2. Physiological/Functional Adaptation
3. Behavioural Adaptation

Structural Adaptation

Structural adaptation refers to the physical features of an organism which enable them to adjust or fit into environmental conditions.

Adaptations of aquatic organism.

Movement:

1. Streamlined shape for easy movement in water e.g. Tilapia fish
2. Presence of fins for swimming
3. Presence of webbed toes as found in ducks.

Breathing / Respiration

1. Some aquatic organisms exchange gases through their body surface by diffusion
2. Presence of gills by fishes, tadpoles for respiration

Buoyancy

1. Presence of swim bladder in fishes helps them to move up and down in water
2. Some zooplankton have small size and expanded shape which keeps them afloat.

Adaptations for Avoiding Predators

1. Presence of lateral lines to detect vibration in water
2. Counter shading in fishes
3. Presence of fins for swimming
4. Fast movement
5. Fearsome appearance, mimicry, feigning death when touched

Physiological Adaptation

Physiological adaptations refers to the physiological adjustment within an organism in response to an improved ability to cope with the changing environment.

1. For retention inside the host

(a) Tapeworm at the larval stage form protective cysts inside the host

(b) Intestinal enzymes secrete anti-digestive enzymes making it difficult to be digested by the host enzymes.

Structural Adaptations for Feeding in Birds

The mouths of birds have been modified to form beaks. The beaks and feet of birds are specialized based on their mode of feeding

These adaptations allow them to feed on a wide range of diets such as fruits, insects, nectar, seeds, fish etc.

Bird – Eagles, Hawks

Adaptations (modification of beaks) – Hooked beaks for tearing and ripping flesh Hooked and sharp claws for grasping prey

Bald Eagle

Bird – Sparrows and Finches

Adaptations (modification of beaks) – Short and conical beaks allow them to pick up and crack seeds

Sparrow

Bird – Kingfishers

Adaptations (modification of beaks) – They have long, straight beaks with sharp edges that allow, them to grip slippery fishes

Kingfisher

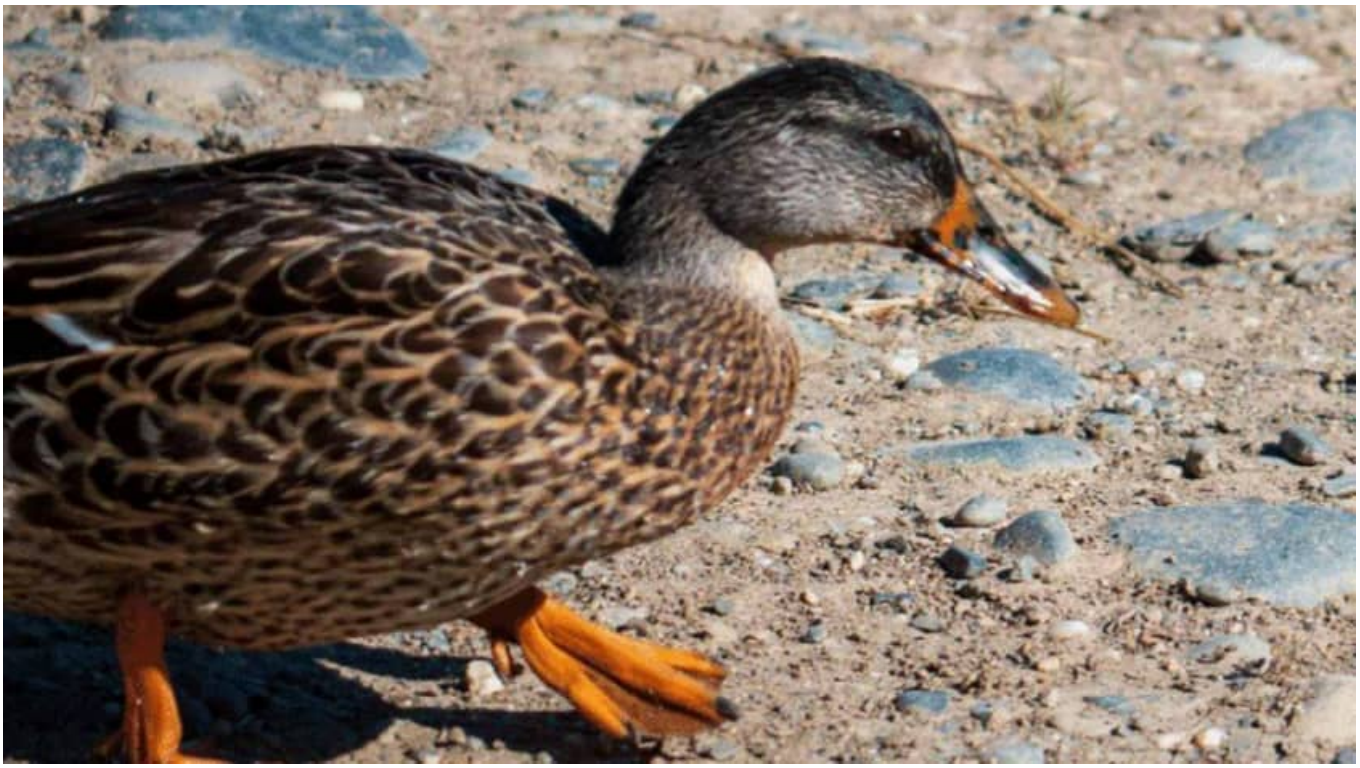
Bird – Woodpeckers

Adaptations (modification of beaks) – They have strong and pointed beaks which can be probe holes into trees. They also have long and sticky tongues to catch insects

Woodpecker

Bird – Water fowls e.g duck

Adaptations (modification of beaks) – They have flat and broad beaks that act as strainers to filter food mud and water. They also have webbed feet to swim quickly in water



duck

Adaptations for Water Conservation in Plants

Xerophytes:

These are plants that live in areas of prolonged drought in their habitat.

Adaptations

1. Leaves are reduced to tiny sheaths at the nodes e.g. *Casuarina* to avoid loss of water by transpiration.
2. Presence of sunken stomata that lies in the grooves of the upper surface e.g. marram grass, reduces the rate of transpiration.
3. The leaves are modified into thorns to reduce loss of water through transpiration e.g. cactus
4. Presence of thick waxy curticle on the surface of leaves reduces loss of water through transpiration
5. Presence of thick bark which cover the buds during bush fires e.g. *Danieillia oliveri*
6. They possess fleshy, Stem for storing water which is made available to plants during drought.

Cactus

Mesophytes

Mesophytes are terrestrial plants which are neither adapted to dry or wet environment. They have several adaptations for conserving water, these include

1. Presence of a well-developed root system to allow it to obtain moisture deep within the ground.
2. Presence of a layer of waxy cuticle on the surface of leaves and guard cells. This control and stomata size and consequently, the amount of water loss.
3. Presence of broad thin leaves to increase surface area for absorption of sunlight for photosynthesis.
4. Examples of mesophytes are *Iroko, Mahogany Obeche*

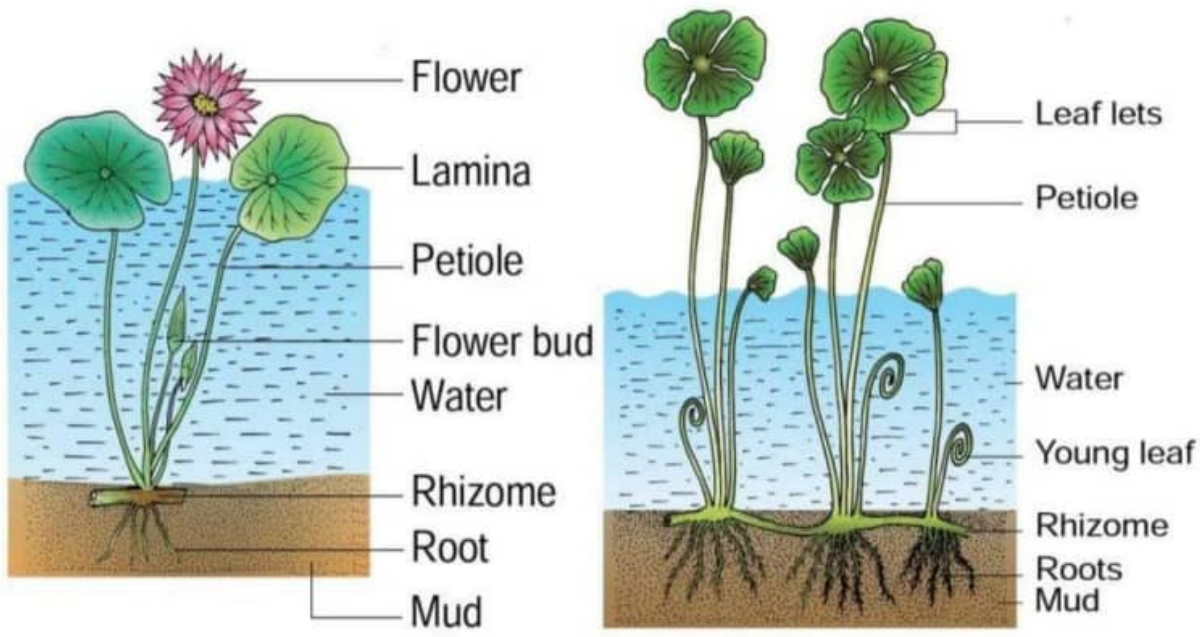
Mahogany Tree

Hydrophytes

These are plants which live completely or partially submerged in water. They are completely adapted to living in water or wet places. Some hydrophytes live in waterlogged soil such as mangrove swamps

Adaptation

1. Floating plants e.g. water hyacinth. Presence of flat, circular leaves helps to distribute weight over the surface of the water so that they can remain afloat
2. In partially submerged plants such as water lily, the stomata are on the upper epidermis to facilitate gaseous exchange through the stomata
3. Floating plants have light bodies that they can remain afloat through up thrust by the water.
4. Waterlogged plants such as mangrove plants e.g Avicennia have their roots buried in oxygen-deficient mud but have special breathing roots called pneumatophores which projects above the waterlogged surface through the opening at pneumatophores, oxygen can pass downwards into the roots
5. Submerged plants have air storage tissue known as lacuna to provide sufficient oxygen during respiration.



Rooted floating hydrophyte

POLLUTION

Pollution

Pollution is the release of toxic or harmful substances into the environment to an extent that it causes damage to man and his resources

When harmful substances are released to the environment such as water, air or land to the level when they become toxic to man, animals and plants, the environment is described as polluted.

Types of Pollution

There are four main types of pollution,

They include

1. Air pollution
2. Water pollution
3. Land pollution
4. Noise pollution

The harmful substances that cause pollution are known as pollutants.

Air Pollution

The main air pollutants, their sources and effects are outlined below.

Air Pollutant	**Sources**	**Effects**
1. Carbon Monoxide	Exhaust fumes of cars & Industrial processes.	Carbon Monoxide combines with haemoglobin in the RBC to form carboxy-haemoglobin. This reduces the capacity of the blood to transport oxygen. This may lead to death in high concentration
2. Sulphur dioxide SO_2	Burning of fossils fuels e.g. coals & natural gas.	Sulphur dioxide damages the eyes, air passages & lungs. Prolonged exposure to $S0_2$ is linked to respiratory diseases. SO2 reacts with rainwater to form acids rain which is linked to the death of fishes in the water.
3. Nitrogen oxides	Burning of fossil fuels. Electrical discharges in air	Nitrogen oxides react with water to form acid rain which corrodes metallic objects. Skin irritation and respiratory diseases.

4. Smoke and soot	Burning of wastes from Industries, machines and coal	Smoke reduces visibility. It causes suffocation. It blackens paint & buildings. Soot can reduce photosynthesis when they cover the leaves of plants.
5. Dust particles	Human activities such as construction, mining, Industrial sites.	It reduces visibility. Irritation of the respiratory tract leading to cough and catarrh.
6. Pollen grains	Flowering plants	Inhalation triggers allergic reactions in some people.
7. Chloroflouro-Carbon (CFC)	Refrigerators and air conditioners.	They breakdown the ozone layer allowing more ultraviolet light to reach the earth.
8. Carbon – dioxide (CO_2)	Burning of organic Compound	CO_2 forms a layer over the earth, trapping the heat radiated from the earth's surface. This is known as the greenhouse effect leading to global warming.
9. Lead	Lead smelter, waste incinerator, Lead acid battery manufacturer	High concentration in the body may cause cramps. Loss of control of the hands & feet. May lead to coma and death.

Ways of Reducing Air Pollution

The following are ways by which air pollution can be reduced

1. Legislation against indiscrimination burning that may bring about smoke
2. Encourage the use of non-fossil fuels in factories sited in densely populated areas
3. Industries should be sited away from residential areas
4. Provision of filters or absorbers to be worn around mining areas so as to reduce pollution from waste gases
5. Use fume chambers to discharge chemical wastes into the air
6. The use of ozone-friendly products should be encouraged
7. Alkalis should be used to neutralize acidic waste products from factories before they are released into the environment.

Water Pollution

Wastes materials dumped into water bodies pollute the water and affect the surrounding community and as such habitats. Major pollutants, their sources, and harmful effects are outlined below.

Water pollutant	**Sources**	**Effects**
1. Sewage.	Sewage system	Untreated sewage contains disease-causing organisms. Growth of pathogens is encouraged such as Cholera causing pathogen. May lead to the deaths of aquatic organisms. It makes water unfit for human consumption
2. Fertilizers and pesticides.	Washed into water bodies by erosion	It makes water unfit for human consumption. Aquatic organisms are killed. Algal bloom depleting the water bodies of oxygen.
3. Crude oil spillage.	Loading and off-loading of oil tankers. Oil drilling.	It makes the water unfit for human consumption. It affects the food chain following the death of some organisms. Destroys aquatic plants and animals
4. Inorganic wastes.	Industries- wastes containing mercury.	Kills aquatic animals, as in mercury poisoning.

Ways of Reducing Water Pollution

1. Treat sewage before it is discharged into water bodies
2. Proper refuse and sewage disposal
3. Recycling of industrial effluents
4. Public enlightenment on proper refuse and waste disposal
5. Organic fertilizers should be used in the cultivation of crops instead of inorganic fertilizers

POLLUTION II

Soil Pollution

The major pollutants of soil, their sources and harmful effects are discussed below:

Soil pollution can be caused by sewage, refuse, metal scraps, crude oil spillage etc.

	Soil Pollutants	**Sources**	**Effects**
1.	Sewage	Homes & offices	Offensive odour Breeding ground for pathogens.
2.	Refuse	Markets, homes, offices, Industries	Brings about an offensive odour when they decay Can cause respiratory disorder
3.	Metal scraps	Abandoned vehicles and machines	Prevents effective use of land Occupies spaces
4.	Pesticides and Fertilizers	Pesticides sprayed on crops	Useful soil organisms are destroyed Excessive application increase soil acidity

5.	Chemicals	From industries	Poisonous to plants and animals
6.	Crude oil spillage	Oil drilling tankers loaded with oil	Destroy the fertility of the soil. Aquatic life is destroyed
7.	Glass particles	Glass companies, industries	Cause injuries to man and animals Prevents effective use of land since it does not decay

Control of Soil Pollution

1. Burn refuses in incinerators
2. Treatment of sewage before disposal to make them less hazardous
3. Legislation against illegal dumping of toxic wastes
4. Reduce the use of inorganic fertilizers & pesticides
5. Recycle waste materials such as paper, plastic materials
6. Reforestation

Noise Pollution

The main noise pollutants are aviation noise, locomotive noise, car horns and sirens, high-pitched musical notes from loudspeakers, noise from generators, noise from thunderstorms, etc.

Effects of Noise Pollution

1. Causes loss of hearing and deafness
2. Can lead to high blood pressure or hypertension
3. Changes in behaviour
4. Emotional disorder, lack of concentration, and anxiety
5. Short temperedness and general irritation

Control of Noise Pollution

1. Legislature on the use of loudspeakers, in public places
2. The use of heavy guns should be banned
3. Airports and railways should be banned sited away from residential areas
4. Installation of soundproof generators should be encouraged.

CONSERVATION OF NATURAL RESOURCES

Meaning of Conservation

Conservation is the Protection and preservation of natural resources in the environment to ensure their continuous availability in their original nature.

The important renewable resources are water, air, soil, wildlife, and forest. Non – renewable resources are resources which when exhausted cannot be replaced e.g. petroleum, coal, tin, etc.

Methods of Conserving Natural Resources

Forest & Wildlife Conservation

(i) Establishment of game reserves or national parks

(ii) Prohibition of hunting of wildlife or other activities that threaten wildlife

(iii) Endangered species can be bred in zoo's and wildlife park and released later into the forest

(iv) Indiscriminate bush burning should be prohibited

(v) Enlightenment on the values of wildlife

(vi) Laws that prohibit, illegal logging, loading and other activities that destroy the ecosystem should be enforced

(vii) Reforestation should be encouraged.

Soil Conservation

Soil conservation helps to preserve the fertility of the soil and sustain food production for future generation.

Ways to Conserve and Maintain the Fertility of the Soil Include;

(i) Good cultural practices e.g. crop rotation so as to prevent leaching, erosion etc.

(ii) Proper irrigation

(iii) Prudent use of fertilisers

(iv) Prevention of bush burning which may expose soil to erosion

(v) Avoid land pollution

(vi) Indiscriminate felling of trees should be discouraged which expose the soil to agents of erosion

Methods of Conserving Water

(i) Recycling of water at the treatment plants

(ii) Legislation to prohibit the dumping of refuse and sewage in water bodies

(iii) Water pipes and taps should be checked regularly to avoid leakage

(iv) Damming of rivers to ensure good water management system

(v) Trees should be planted to provide cover and reduce evaporation from the soil. This will promote water retention.

Methods of Conserving Air

(i) Refuse should be burned using incinerators to prevent smoke or soot from polluting the air

(ii) Proper treatment and disposal of sewage

(iii) Prevent fumes from automobiles and thermal plants from polluting the air.

Conservation of Mineral Resources

(i) Legislation against illegal mining of mineral resources

(ii) Discourage the over dependence on a particular natural resource

(iii) Reusing and recycling of minerals and mineral products

(iv) Advanced technology should be deployed during mining to reduce wastage during mining process

(v) Effective and efficient utilization of available minerals resources

Benefits of Conservation

1. Good conservation efforts leads to improved crop yield and agricultural production

2. Successful forest and wildlife conservation ensures sustainable sources of timber, forest products as well as providing natural habitats for plants and animals and prevention of endangered species from being extended

3. Water conservation efforts ensure adequate supply of good drinking water for humans and animals and preservation of aquatic habitat

4. Conservation of mineral resources ensures the animals are not depleted or used rapidly.

Problems and Difficulties Associated with Conservation

1. Water, air and land pollution
2. Indiscriminate burning of bushes and hunting
3. Occurrence of natural disasters e.g. flood earthquake
4. Erosion as a result of natural winds
5. Overgrazing by cattle
6. Deforestation – indiscriminate falling of trees
7. Oil spillage leading to the destruction of aquatic terrestrial life
8. Poor farming methods

EVALUATION QUESTIONS

1a. Define the term conservation.

b. State five reasons why natural resources need to be conserved

c. List five natural resources that need to be conserved.

2a. Explain ways by which natural resources can be conserved

b. State three problems encountered in conservation of natural resources

SOLUTION

1a. Define the term conservation.

Answer – Conservation is the protection and preservation of natural resources in the environment to ensure their continuous availability in their original nature.

b. State five reasons why natural resources need to be conserved

Answer –

Reasons for conservation of natural resources are:

- To ensure improved crop yield and agricultural production.
- To ensure sustainable sources of timber, forest resources
- To keep the natural habitats of plants and animals by preventing them from being endangered
- To ensure adequate supply of good drinking water for human and animals, for agricultural purposes, and preservation of aquatic habitats
- To ensure continuous availability of energy and raw materials.

c. List five natural resources that need to be conserved.

Answer –

- Water
- Soil
- Forest
- Mineral
- Wildlife/Games

2a. Explain ways by which natural resources can be conserved

Answer –

- Maintaining good farming practices and methods.
- Careful use of fertilizers
- Discourage indiscriminate felling of trees
- Legislation against the destruction of natural resources
- Establishment of game reserves or national parks
- Legislation to prohibit dumping of refuse and sewage in water bodies and around homes
- Re-using and recycling of natural resources such as minerals

b. State three problems encountered in conservation of natural resources

Answer –

- Limited sources of energy
- Limited Land area for development
- Inadequate guards
- Insufficient funding
- Bush burning
- Overgrazing
- Overfishing

PESTS AND DISEASES OF CROPS

Pests

What are Pests?

Definition: Pests are living organism that cause physical damage to man, his animals, crops and properties.

Classification of Pests

Pests of crops can be classified according to;

i. The parts of plants they attack

ii. The animal type

Classification of Pests Based on the Parts of Plants they Attack

0% Complete

i. Stem borers:

These pests cause damage to crops such as cereals, the insect larvae bore into the stem of the plant and feed on the stem tissue

ii. Root Feeders:

Root feeders examples include cucumber beetle, root knot nematodes, gnats and larvae of beetles. Root-knot nematodes feed mainly on the roots plants. Their female lays eggs on the root surfaces of tomatoes. The larvae penetrate the roots and feed on the tissue within the root causing the root cells to enlarge, resulting in swollen structures known as knots. This reduces the ability of plants to absorb water from the soil leading to a poor yield of the crop.

iii. Young Shoot Feeders:

The shoot borers or feeders lay eggs on the shoot of plants such as mango. Their eggs hatch into larvae which feed on the shoots leading to wilting. The plant may die as a result of this. Examples include aphids & mealybugs

MEALYBUGS

iv. Pests of Leaves

These pests feed on leaves of plants e.g. grasshoppers, beetles, caterpillars, locust. They cause great damage to crops such as cereals.

Caterpillers

v. Pests of fruits and seeds (Fruit & Seed Feeders)

a. Fruit flies feed on the pulp or seeds of fruits. The fruit fly causes damage to the fruit by causing rots and discolouration. After hatching from the eggs, the larvae penetrate deep into the fruit while feeding causing considerable damage inside the fruit. The affected part then begins to rot and often falls prematurely from the plants.

fruit fly

b. Cotton stainer: It damages crops plant by sucking the sap and destroying the balls and staining them with excrement. The punctured cotton ball may fail to develop and grow and shrink in size.
The economic value of the cotton is reduced by the stain left on the balls

cotton stainer

vi. Pests of Stored Plants

Pest of stored products such as insects infest and destroy stored products e.g. rice, wheat, maize, sorghum.

These pests include beetles, weevils, moths. With the aid of the rostrum, the weevils bores holes into harvested products. The eggs hatch into larvae which eat the plant material surrounding them. The weevils may cause serious damage if the plant material is used for human consumption.

weevil

Classification of Pests Based on the Type of Animal

i. Invertebrates e.g. nematodes, arthropods insects and larvae of insects

ii. Vertebrates pest

Vertebrates' pests include animals such as birds and mammals such as squirrels, bats, pigs, rats, rabbits, monkeys. Rats are regarded as the most destructive crop pests. They feed on stored grains as well as pre-harvest crops.

Vertebrate pests cause damage to crops in the following ways

i. Grazing or digging up the roots of crops

ii. Feeding on the grains

Life Cycle of Common Pests of Crops

Aphids

Aphids have a complicated life cycle. Wingless females are known as "stem mothers" can reproduce without fertilization (parthenogenesis). The mouthparts of aphids are modified for piercing and sucking.

They obtain their food by sucking plant juices or the blood of other animals. e.g water boatman prey on other pond creatures e.g frogs while "cuckoo – spit" insects draw fluids from plants. These groups of insects have an incomplete metamorphosis, there is no pupal stage but a series of moults in which the nymph gradually becomes a mature adult.

There are over 400 species and varieties of aphids. In October, the females usually lay eggs on the stem of trees or shrubs. The eggs are black with thick shells and can withstand extremes of temperatures.

In march the eggs hatch out into wingless female nymphs which resemble the adult. No males are hatched at all. They feed on the shoots and leaves of trees on which they hatch. They feed and grow by moulting and become adults

Egg →→ Nymph →→ Adult

Grasshoppers

Grasshoppers feed mainly on grasses and the leaves of plants. It has an incomplete metamorphosis. The life cycle has only three stages: egg, nymph, and adult. The process of development from egg to adult grasshopper is known as metamorphosis.

Grasshopper has a life span of about 60days.

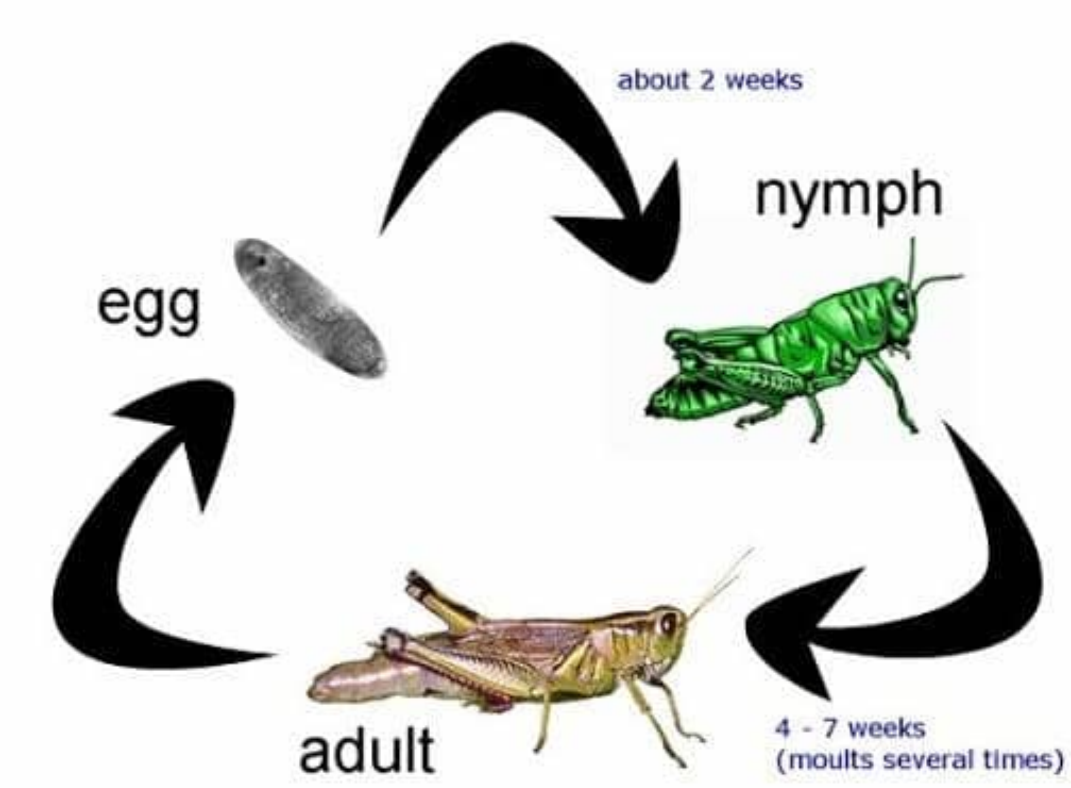
The Egg stage:

After fertilization, the female grasshopper lays eggs underneath the soil or on leaf litters. The female then sprays a sticky substance on the eggs to form an egg pod which contains between 10 – 300 eggs. The eggs remain under the soil or amongst leaf litters during the season, the eggs hatch when the conditions become favourable into nymphs which have to burrow their way out of the ground and crawl up to plants.

The Nymph:

As the nymph emerge from their respective egg. They attach themselves to plant foliage to consume. The nymph looks like an adult but sexually immature and the wings are absent. The nymphs undergo five to six stages of moulting before it becomes an adult.

This stage of the nymph life span last for about six weeks until it transform into an adult.



The Adults:

In about 25 – 30 days, the nymph starts to develop wings. Grasshoppers acquire sexual maturity within 15days.

Unlike the nymph, the adult grasshopper has more mobility and the ability to hunt and escape predators. They have about a 50% chance of survival even though they are surrounded by many predators.

CONTROL OF PESTS

Methods of Pest Control

Methods of pest control include

1. Physical control
2. Cultural control
3. Biological control
4. Chemical control

(1) Physical Method:

This refers to mechanical or hand control where the pest is actually attacked and destroyed. It involves.

(i) Removal of pests by hand (hand picking)

(ii) Setting up of barriers that will prevent further destruction of one's plant

(iii) Use of traps as nets, sticky boards

(iv) Subjecting crops seeds to steam sterilization to kill the insect pest.

(v) Sun – drying of grains

(vi) Storage and at low temperatures to prevent breeding of insect pests

(2) Cultural Methods

Cultural methods of pest control employ practices that make the environment less attractive to pests and less favourable for their survival, growth and reproduction.

These methods are aimed at reducing the exposure of plants to infection. Cultural control involves, manipulation of cultural practices for reducing or avoiding pest damage to crops.

Cropping techniques include ploughing, raking and hoeing, pruning pest-free seed materials, destruction of weed hosts, intercropping, earthing up to 30 DAP e.g. cowpea in sorghum 1:4 ration, crop rotation, mixed cropping

(3) Biological Control

The biological method of pest control involves the deliberate introduction of natural enemies of the insect pests such as predators, parasitoids, and pathogens

i. Natural predators

Predators such as ladybirds are free-living but feed on aphids which cause extensive damage to our crops. Ladybirds feed selectively on aphids thereby helping to control the population of aphids

ii. Parasitoids

Parasitoids lay their eggs on or in the body of an insect host which is then used for developing larvae. The host is eventually killed. Examples of insect parasitoids are wasps and flies that have a narrow host range

iii. Pathogens:

Pathogenic microorganisms such as bacteria, viruses, and fungi can be used to cause diseases in the pest. They kill their host and are relatively host-specific. Various microbial insect diseases occur naturally but may be used as biological pesticides.

iv. Sterilization:

Irradiation can be used to make the male insects sterile. It involves exposing the male insects to X-rays or gamma rays over several generations before they are released into the natural population. This method helps control reproduction. If the population of the pests is controlled, the rate of damage to crops is also controlled.

(4) Chemical Control

The most common method of pest control is the use of pesticides, chemicals that either inhibit their development or kill them.

They may be in form of sprays or powder. A single application is usually sufficient to keep pests away. However, during outbreaks, the repeated application is necessary to curtail their spread.

Diseases of Crops and their Agents

Fungal Diseases

Disease	**Mode of transmission**	**Effects**	**Control**
Groundnut rosette (virus)	Transmitted by aphids and leaf hoppers	-Yellow & green patches appears on leaves. -Distortion of leaves	-Plant resistant varieties
Cassava mosaic (virus)	Transmitted by the whitefly	-Mottling of leaves -Poor chlorophyll Formation	-Plant resistant varieties -Use pesticides to control insect
Swollen shoot disease of cocoa (fungus)	Transmitted by Mealybugs	-Distortion of leaves -Mottling of leaves	-Destroy the vectors -cut down and burn infected plants
Root knot of Okra	Transmitted by knot nematodes	-Development of knots, on the roots, makes the root unable to absorb water	-Grow resistant varieties -Good cultural practices
Bacteria wilt of tomatoes	Infection is through wounds	-Turns vascular tissue brown -Wilting of leaves	-Plant resistant varieties -Crop rotation
Black Pod disease of cocoa	Spores are spread by wind	-The infected pod shows some little yellow spots -Yellow spots turn Brown spots and enlarge eventually to black	-Spray infected crop fungicide -Burn infested pods
Rust of maize	The Spores of the Fungus are carried by wind	-Coloured patches (Yellow / Brown) on leaves	-Plant resistant varieties -Good cultural practices
Powdering mildew of wheat (fungus)	Spores of the fungus are spread by wind	-White patches on the upper & lower surfaces of the leaves	-Plant resistant varieties of wheat

			-Apply fungicide
Soft rot of vegetables	Infection through damaged parts of the plant	-Reduces storage tissues of the plant into a watery, slimy mass	-Destroy refuse dumps in the farms to remove sources of infection -Avoid bruising the plant when harvesting
Blight of tomato	Spread by vector	-Formation of temporary spots on the leaves which dry up & fall off the plant.	-Plant resistant varieties -Apply pesticides -Crop rotation

EVALUATION QUESTIONS

1a. List four biological pest control methods

b. What are the cultural methods used in controlling pests?

ci. List two bacterial and two fungal diseases of crops

ii. State the mode of spread and control measures of the diseases listed above.

SOLUTION

1a. List four biological pest control methods

Answer –

- Use of natural predators e.g. birds
- Parasitoids that destroy insect pests like wasps and flies
- Pathogens like bacteria infect the pests and kill them
- Sterilization so that the pests won't be able to reproduce.

b. What are the cultural methods used in controlling pests?

Answer –

- Using pest-free seeds
- Destruction of weeds that serve as hosts to pests

- Practicing crop rotation and mixed cropping
- Pruning out pest infected parts.

ci. List two bacterial and two fungal diseases of crops

Answer –

Bacteria diseases of crops are:

Bacteria blight in Cotton

Bacteria wilt in Tomatoes

Fungal diseases of crops are:

Maize rust

Black pod of Cocoa

ii. State the mode of spread and control measures of the diseases listed above.

Mode of spread and control measures

Disease	**Mode of transmission**	**Control**
Bacteria blight in Cotton	Carried by wind or insects, waterlogging conditions.	Use disease-resistant varieties for planting. Dust seed with Agrosan 5w (anti-biotic) before planting.
Bacteria wilt in Tomatoes	Through cuts on the plant	Practice crop rotation Plant disease-resistant varieties
Maize rust	Spores of fungus carried by the wind.	Plant disease-resistant varieties
Black pod of Cocoa	Spores spreading by rain splash, insects, and animals.	Spray fungicides e.g. Bordeaux mixture Burn all infected pod

REPRODUCTIVE SYSTEM IN VERTEBRATES I

External and Internal Fertilization (Oviparity, Viviparity and Ovoviparity)

Reproduction is a fundamental feature of life. Organisms exists as a result of reproduction. Reproduction is a biological process by which new offsprings are produced from their parents. The reproductive processes in vertebrates vary depending on their environment whether aquatic or terrestrial. Most aquatic organisms require water for fertilization. Fertilization in animals may be external or internal

External Fertilization

External fertilization occurs commonly in aquatic habitats. In this mode of fertilization, the eggs and sperm are released into the water. After the sperm reaches the egg fertilization can then take place outside the body of the organism. This type of fertilization is common in fishes and amphibians, which usually lay many small eggs to ensure that they get fertilized since many of the eggs are eaten by other animals.

Internal Fertilization

Internal fertilization occurs in most reptiles, birds, and mammals. It occurs most often in terrestrial animals, although some aquatic animals also use this method. The females do not release their eggs to the external environment to avoid the risk of desiccation.
There are three ways offspring are produced following internal fertilization: oviparity, viviparity and ovoviparity.

Oviparity

In oviparity, the fertilized eggs are laid outside the female's body and develop there. Fertilization may be internal or external. Oviparity occurs in all birds, many fishes, most amphibians, some reptiles, insects, and some mammals such as the platypus.

Reptiles and insects produce leathery eggs, while birds and turtles produce eggs with high concentration of calcium carbonate in the shell, making them hard. They obtain all their nutrients from the egg white or albumen and yolk in the egg.

Viviparity

In viviparous animals, the young ones develop within the female, receiving nourishment from the mothers blood through a placenta. The offspring develops in the female and is born alive.

DEER GIVING BIRTH

Viviparity occurs most commonly in mammals, some cartilaginous fishes and a few reptiles. Nutrients and oxygen are transferred from the placenta via the umbilical cord. The mother gives birth to the young ones alive when it is fully developed.

Ovoviparity

In ovoviparous animals, the fertilized eggs are retained in the females body, but the embryo obtains its nourishment from the egg's yolk; the young are fully developed when they are hatched and released from the body of the mother. Ovoviparity occurs in some bony fish, some sharks, some reptiles.

Ovoviparous Animal – Shark

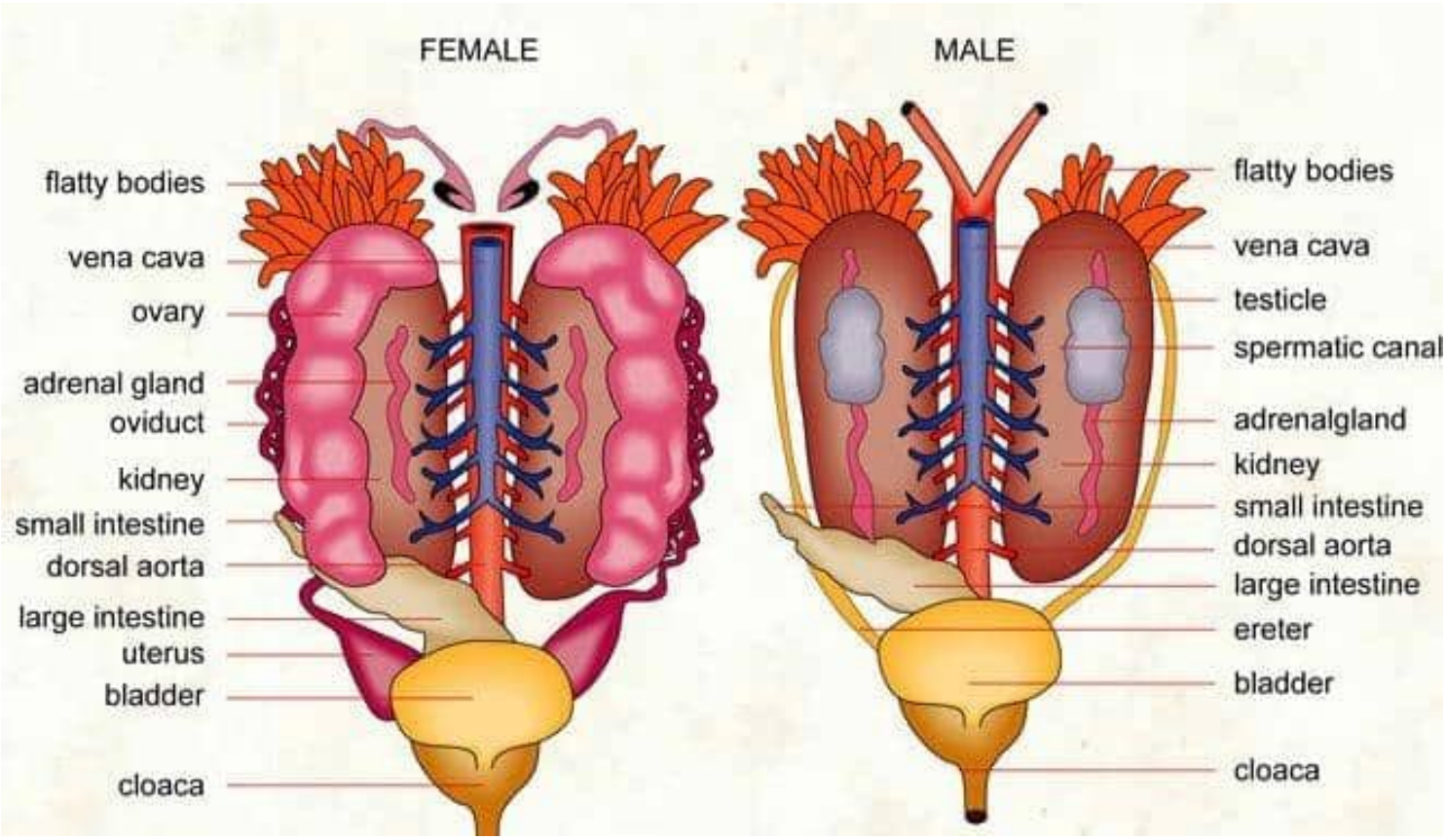
Key Terms

- **oviparous**: egg-laying; depositing eggs that develop and hatch outside the body as a reproductive strategy
- **viviparous**: being born alive, as are most mammals, some reptiles, and a few fish (as opposed to being laid as an egg)
- **ovoviparity**: eggs are retained in the female, but the embryo obtains its nourishment from the egg's yolk

Female Reproductive System

The reproductive system is closely associated with the excretory system in vertebrates, and is known as urogenital system. In fishes and amphibians, they have two ovaries that links the oviducts to the uterus and the cloaca as shown in the diagram below. The eggs are produced by the ovaries and are conveyed through the oviducts to the cloaca.

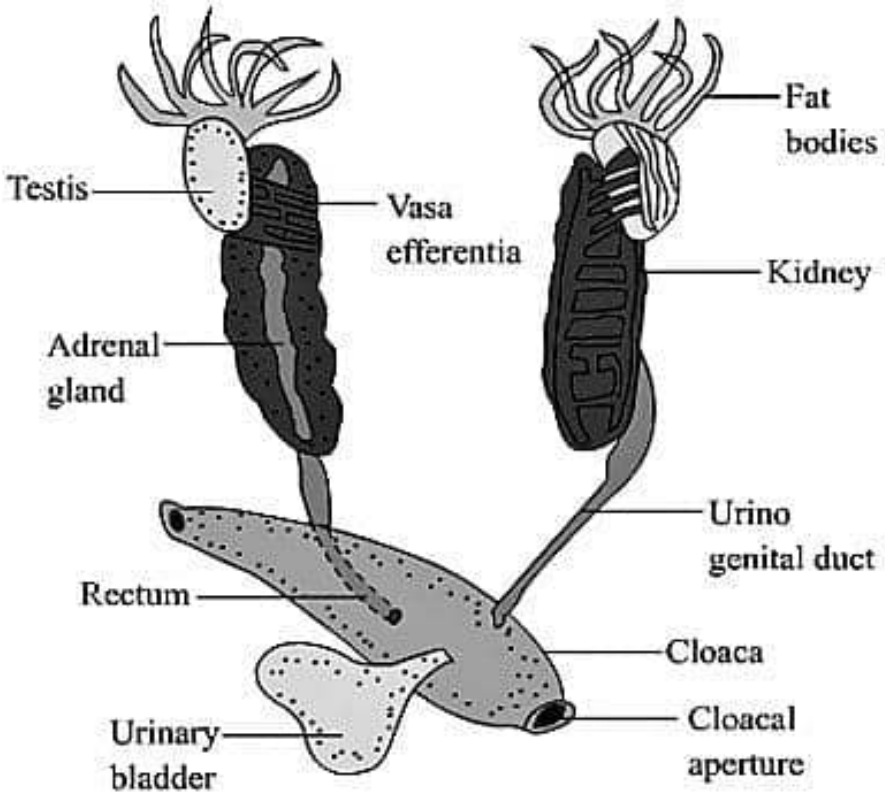
The eggs of most fishes contain yolk which provides nourishment for the growth and development of the embryo.



Urogenital Organs of a Frog

Male Reproductive system

The male reproductive system of fishes and amphibians consists of the following; a pair of testes, vasa efferentia. The testes are located at the anterior part of the kidneys and connected to the vasa efferentia and linked to the kidneys. The sperms are produced by the testes.



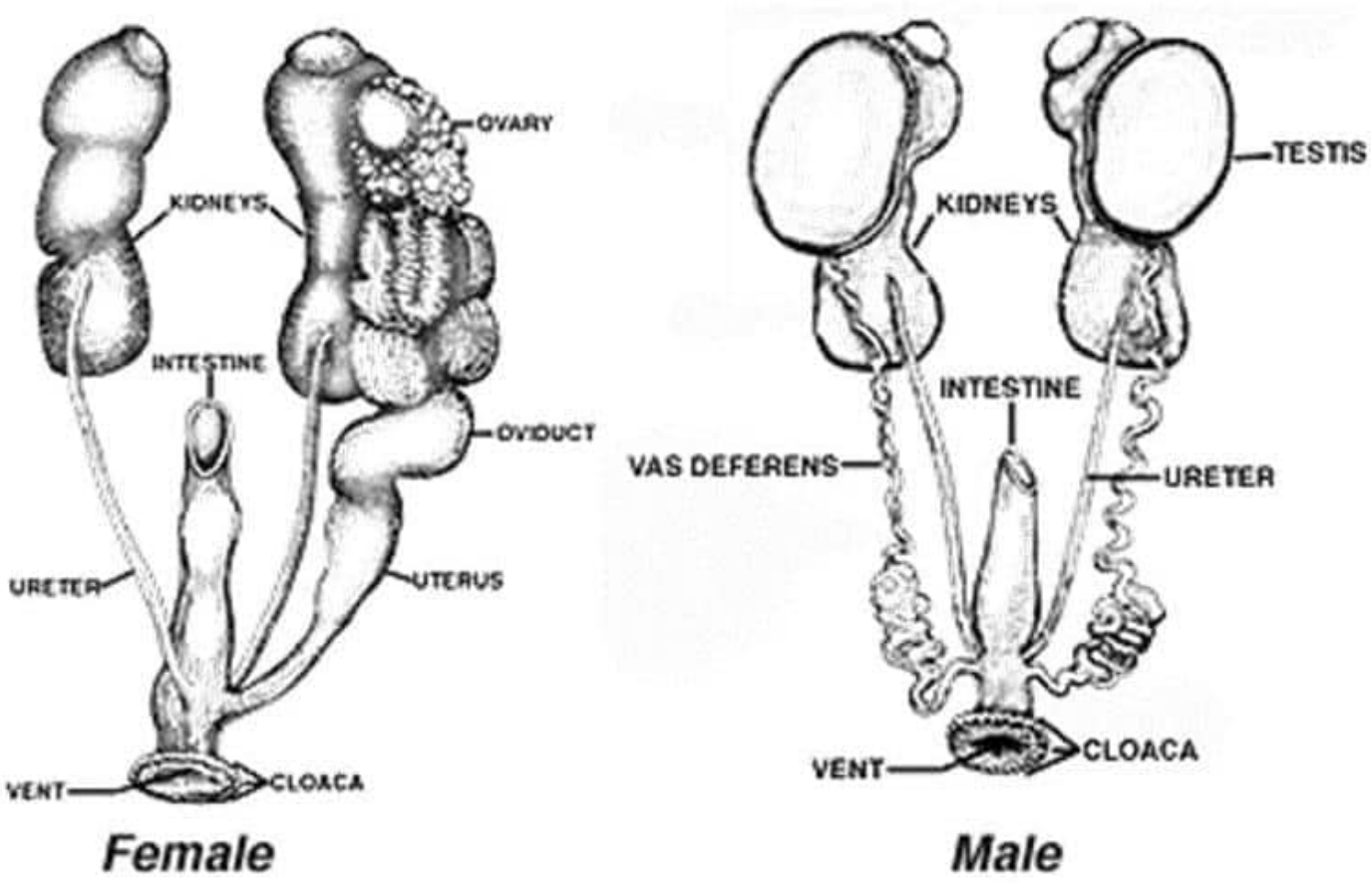
Frog Male Reproductive System

Male Reproductive System in Birds

The male reproductive system consists of a pair of testes located above the kidneys, vas deferens, seminal sac, cloaca.

The testis produces the sperm which is transported through the vas deferens and stored in the seminal sac. In some birds, an equivalent of the penis in mammals, known as the phallus is present at the back of the cloaca in some birds such as ducks and turkey.

During mating, the male presses his cloaca to the females and releases sperm. The female's single ovary releases eggs into a long, funnel-shaped oviduct where they are fertilized by sperm. This usually takes place quickly.



Reproductive System in Birds

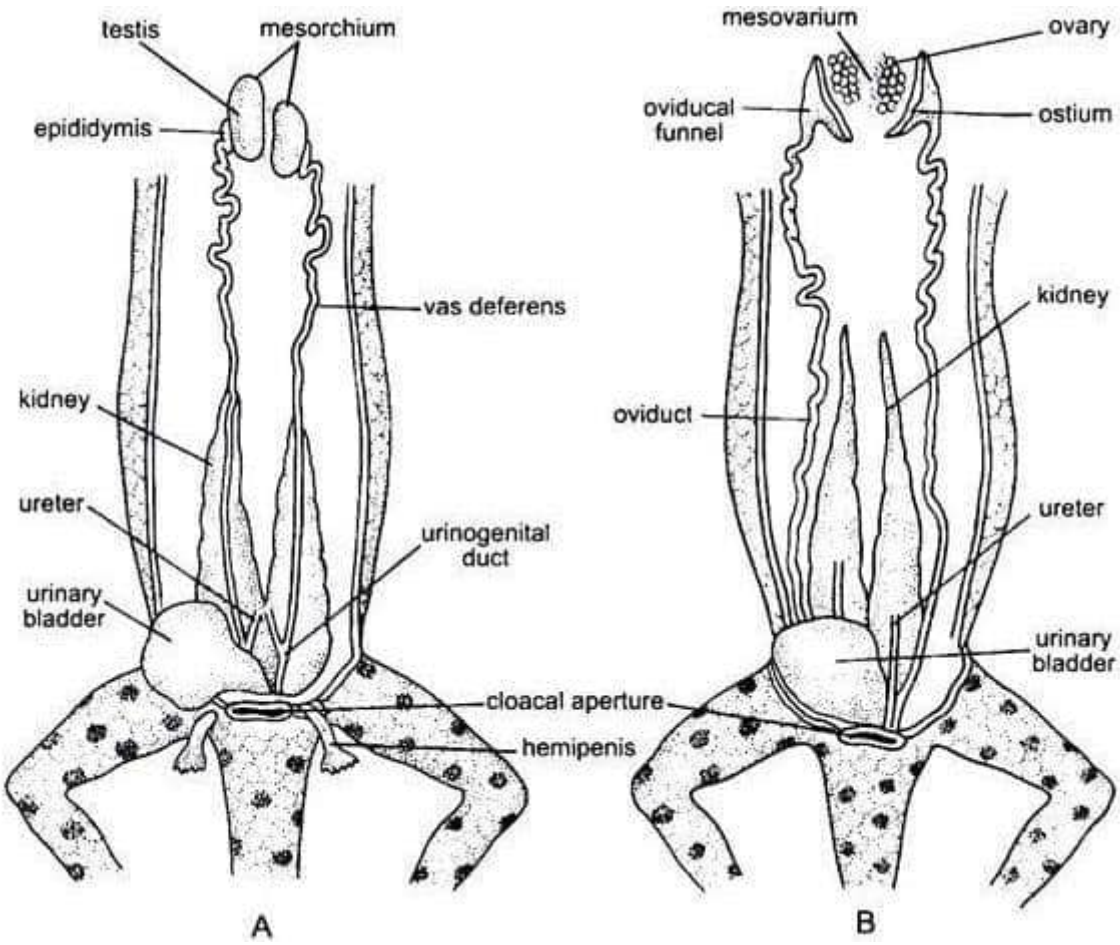
Female Reproductive System in Birds

In female birds, only the left ovary is functional while the right ovary is usually undeveloped. The left ovary is joined to the oviduct which opens into the cloaca. The single ovary produces the egg, which is released into the oviduct. When they are fertilized by the sperms, the eggs pass through the oviduct and are released via the cloaca to the external environment.

Reproductive Systems in Reptiles

Male Reproductive Systems in Reptiles

The male reproductive system of reptiles e.g. lizard consists of a pair of testes located in the abdomen. The sperm produced by the testes are conducted to tiny tubes known as vasa deferentia and to the epididymis which are long coiled tubes, and the penis which releases sperm into the female for internal fertilization.



Urinogenital System of a Lizard | A – Male, B – Female

Female Reproductive System in Reptiles

The female reproductive system consists of two ovaries located close to the oviducts which convey the eggs to the uterus before it enters the cloaca.

EVALUATION QUESTIONS

1. Explain the following terms and give an example of an organism in which it occurs:

(i) Oviparity

(ii) Viviparity

(iii) Ovoviviparity

2. Distinguish between internal fertilization and external fertilization.

SOLUTION

1. Explain the following terms and give an example of an organism in which it occurs:

(i) Oviparity

Answer – In oviparity, the fertilized eggs are laid outside the female's body and develop there.

(ii) Viviparity

Answer – Viviparity is the development of the fertilized egg inside the female after which the mother gives birth to the young one alive.

(iii) Ovoviviparity

Answer – Ovoviviparity is the retaining of the fertilized egg within the female's body but the embryo obtains its nourishment from the egg's yolk until it hatches and is released from the mother.

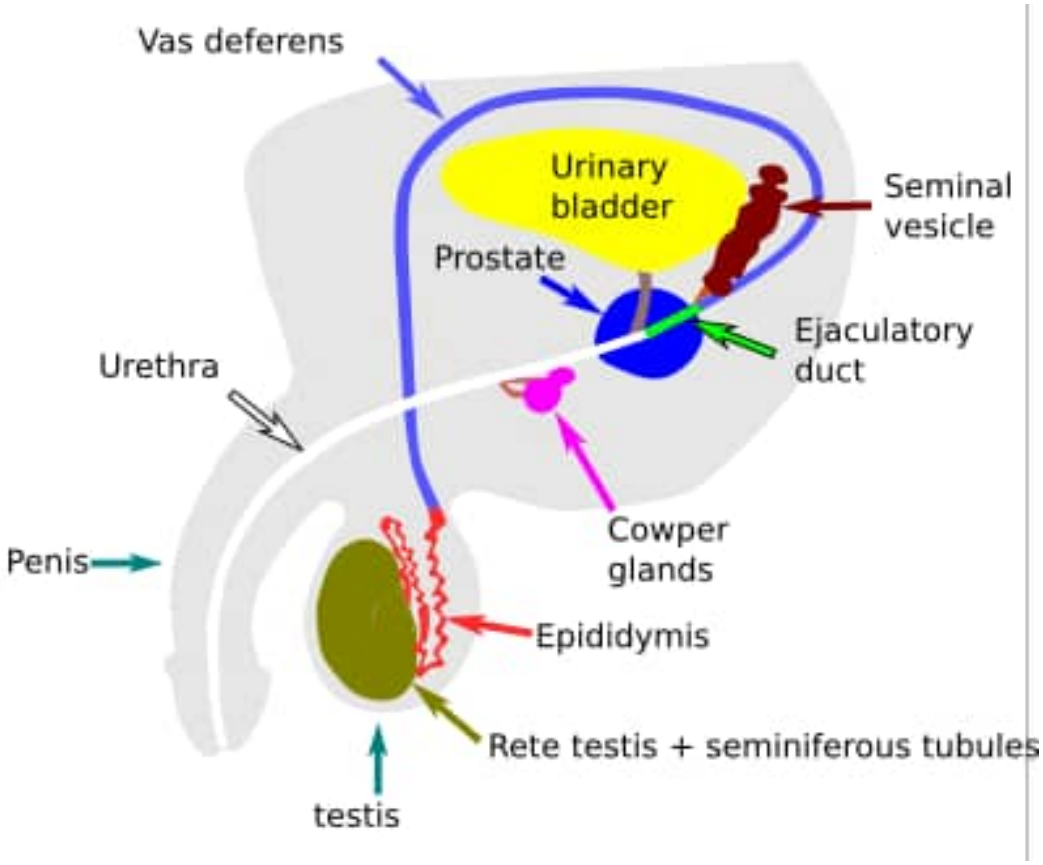
2. Distinguish between internal fertilization and external fertilization.

Answer – External fertilization is the fertilization of the egg outside the body of the female while Internal fertilization is the fertilization of the egg inside the body of the female.

REPRODUCTIVE SYSTEM IN VERTEBRATES II (MAMMALS)

Male Reproductive System of Mammals

The male reproductive system in man consists of testes (testis), vas deferens (sperm duct), penis and glands



There are two testes which are oval shaped and each testis is enclosed in a wrinkled sac called scrotum.

The **scrotum**: It serves as a thermo regulator that protects the sperms from high temperature.

The **testes** lie, outside the body cavity so that they are cooler than the heat of the body which favours rapid sperm production.

Each testis is made up of many coiled tubes called **SEMINIFEROUS TUBULES** (sperm tubules) and interstitial cells which are within the seminiferous tubules.

The **seminiferous tubules** produce sperms while the interstitial cells produce testosterone. The seminiferous tubules lead into the vas deferens which form the epididymis.

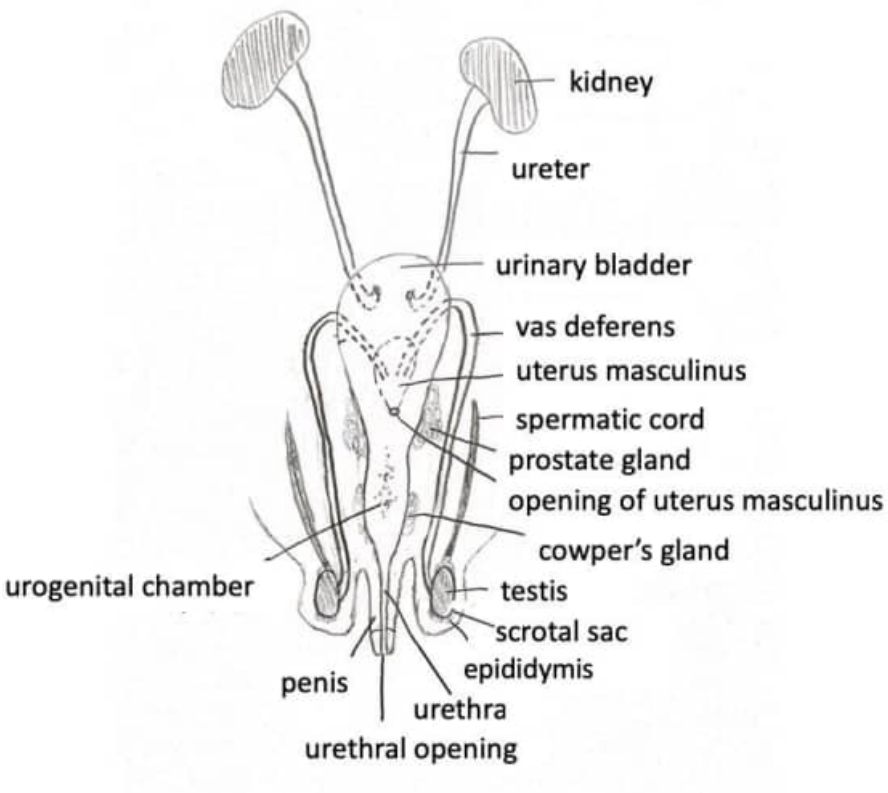
The epididymis is a long coiled tube, about 6m long that rests on the backside of each testicle. It transports and stores sperms cells temporarily. The epididymis leads into a muscular sperm duct vas deferens..

The vas deferens is a long muscular tube that transports mature sperm to the urethra, the tube that carries urine or sperm to the outside of the body.

Seminal vesicles are sac-like pouches that attach to the vas deferens near the base of the bladder. It produces a sugar-rich fluid (fructose) that provides sperm with a source of energy to help them move. Sperm are stored in the two seminal vesicles until ejaculation. The seminal vesicle opens into the urethra.
The fluid of the seminal vesicles makes up most of the volume of man's ejaculatory fluid or semen.

Prostate gland: The prostate gland is a walnut-sized structure located near the urinary bladder in front of the rectum. The prostate gland contributes additional fluid to ejaculate. Prostate fluids help to nourish the sperm. Just below it is the cowper's gland. The prostate and Cowper's gland secrete **seminal fluid** which activates the sperm.

The urethra is the tube that carries urine from the bladder to the outside of the body. It is prolonged into an erectile and intromittent organ called **PENIS** which consists of spongy tissues, muscles, and blood. Before sexual intercourse blood enters the spaces and the penis becomes stiff or turgid.
It is interesting to note that both urine and semen are not passed out at the same time because when the penis is erect, it is difficult to urinate as a muscular valve closes the bladder and when the penis is limp, it is not possible to discharge semen.



Male Reproductive System of a Rabbit

Summary

Functions of Some Parts of the Male Reproductive System

Testes	Produces sperms and more hormones which influence development of sexual characteristics
Scrotum	Act as thermo regulator that protects the sperms from high temperature
Epididymis	Stores sperms temporarily until maturation
Vas Deferens	Caries sperms from epididymis to seminal vesicles
Seminal Vesicle	Stores sperms until ejaculation and secretes part of the seminal fluid.
Prostate Gland	Secretes part of the seminal fluid which activates the sperms, feed and prevent them from sticking together
Cowper's Gland	Secretes part of the seminal fluid in the reproductive organ.
Penis	Erectile organ through which the sperms are introduced into the female reproductive organ.
Urethra	A tube that carries urine from the bladder to the outside. It ejaculates semen when man reaches orgasm.

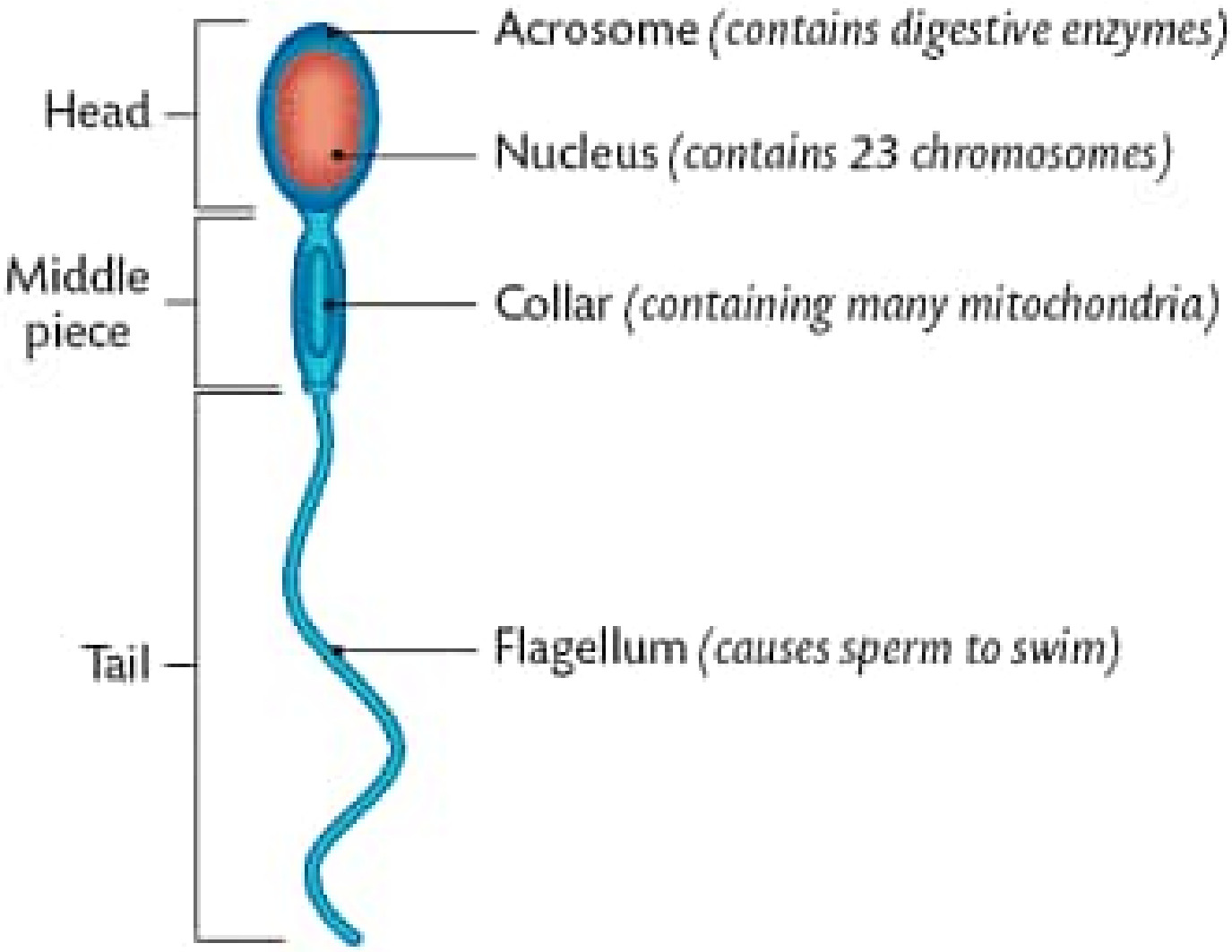
Structure of the Male Gamete (Sperm)

Each sperm has an oval head, a middle piece, and a long whip-like tail or flagellum. The head consists of a large nucleus which contains genetic material which fuses with the nucleus of the egg or ovum.

The tip of the head of spermatozoa is capped by a liquid sac called **ACROSOME** which contains enzymes used to dissolve the egg membrane during fertilization.

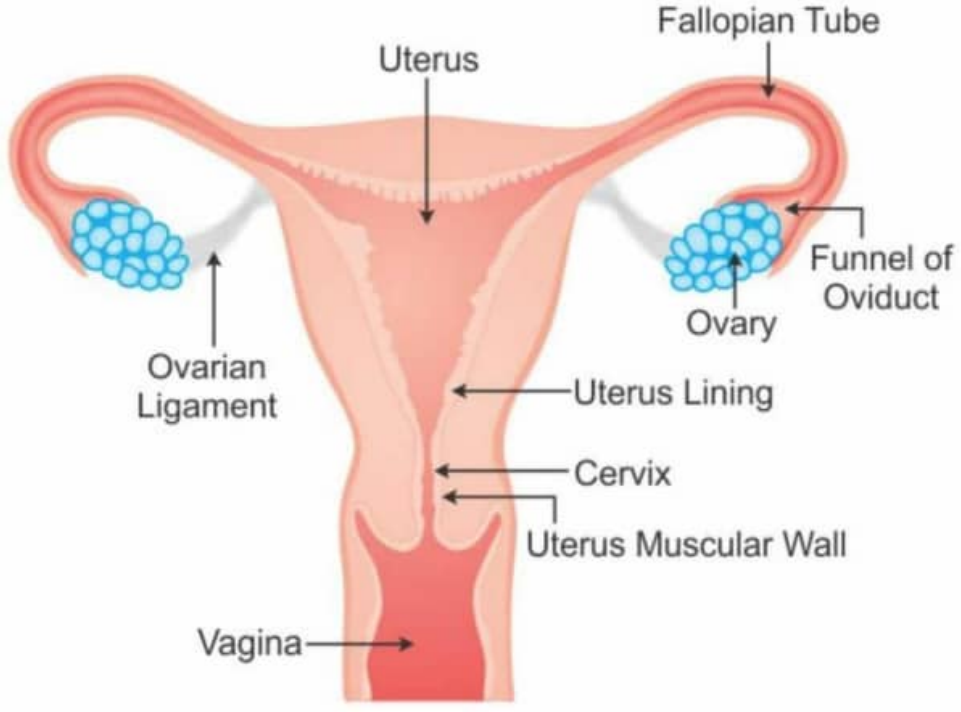
The middle piece contains numerous mitochondria, which generate the energy used by the sperm cell to swim towards the egg.

The long whip–like tail or flagellum at the posterior end of the sperm cell propels the sperm cell.



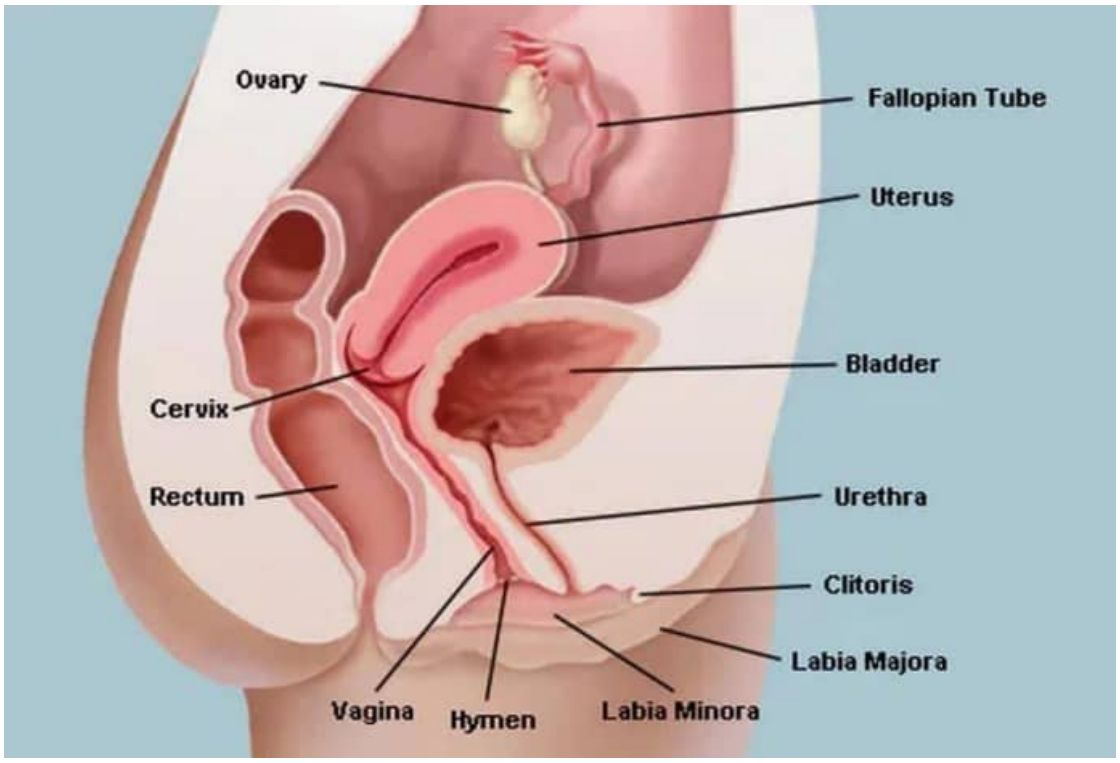
Structure of the human sperm

The Female Reproductive System of a Mammal



The female reproductive system consists of ovaries, oviducts, uterus, vagina and vulva.

There are two oval – shaped ovaries situated below each kidney. The ovaries produces ovum/egg, female sex hormones called oestrogen and progesterone which make the wall of the uterus thicken and become suitable for fertilized ovum. It also influences the development of secondary sexual characteristics in females.



Female Reproductive System of Human

Each ovary is held in position by ligaments, close to the ovary is a funnel-shaped structure known as **the fallopian funnel** which receives the **ovum**.

The fallopian funnel leads to the **fallopian tube** or **oviduct** (9-15cm long). The fertilized egg passes through the tube from the **ovary**. It is the site of fertilization.

The oviduct opens into a wide muscular tube called the **uterus** or **womb**. The implantation of fertilized ovum takes place in the uterus. It receives and cares for the foetus. The uterus is important in expelling the foetus during birth. The uterus leads into a muscular tube called **VAGINA**.

The vagina receives the male organ or penis and sperm cells during sexual intercourse. It also permits the passage for the foetus during birth.

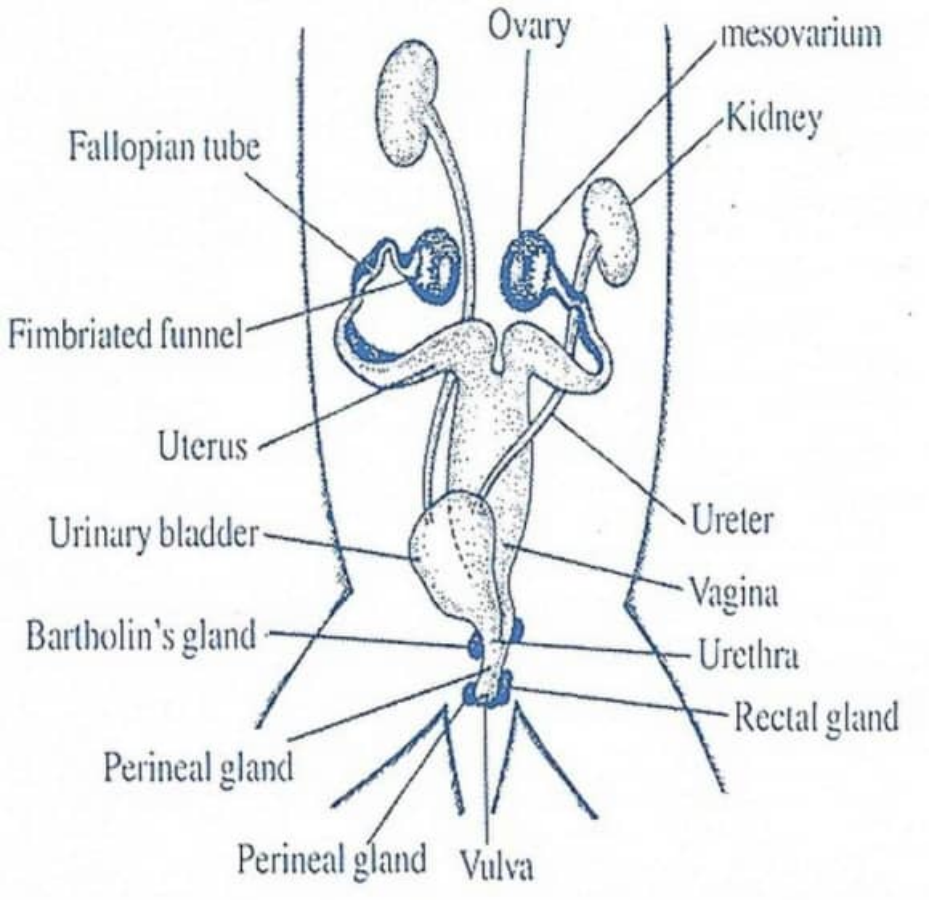
The lower narrow end of the uterus which leads into the vagina is called the **cervix**. It is the entrance to the uterus. The cervix regulates the opening of the vagina.

The opening of the human vagina to the outside is called the **vulv**a. The vulva functions as a passage for the foetus and receives a male organ or penis. The vulva is the outer part of the female genitals. The vulva includes the opening of the vagina (sometimes called the vestibule), the **labia majora** (outer lips), **the labia minora** (inner lips), and the **clitoris**.

In front of the vulva is a small sensitive rod-like structure called the **CLITORIS**. It is erectile and helps to stimulate the female during sexual intercourse.

The urinary passage (**urethra**) and the genital passage (vagina) have separate openings to the outside in females.

The **hymen** may be present at the entrance of the vagina; this tissue may be easily ruptured by sexual or non-sexual activities.



Female Reproductive System of Rabbit

Structure	**Function**
Ovary	Produces ova (or eggs) and the female sex hormones called oestrogen and progesterone
Oviduct / fallopian tube	Carries ovum to the uterus by propulsion aided by tiny cilia in the walls. It is the site of fertilization.
Uterus or womb	where the foetus develops.
Vagina	Birth canal; during labour and delivery. Receives sperm from the penis during intercourse
Cervix	A ring of muscle separating the uterus from the vagina.
Clitoris	A sensitive structure near the entrance into the vagina Helps to stimulate the female during sexual intercourse
Vulva	Outer parts of the female reproductive organ. Allows passage of penis into the vagina and serves as a passage of urine out of the body

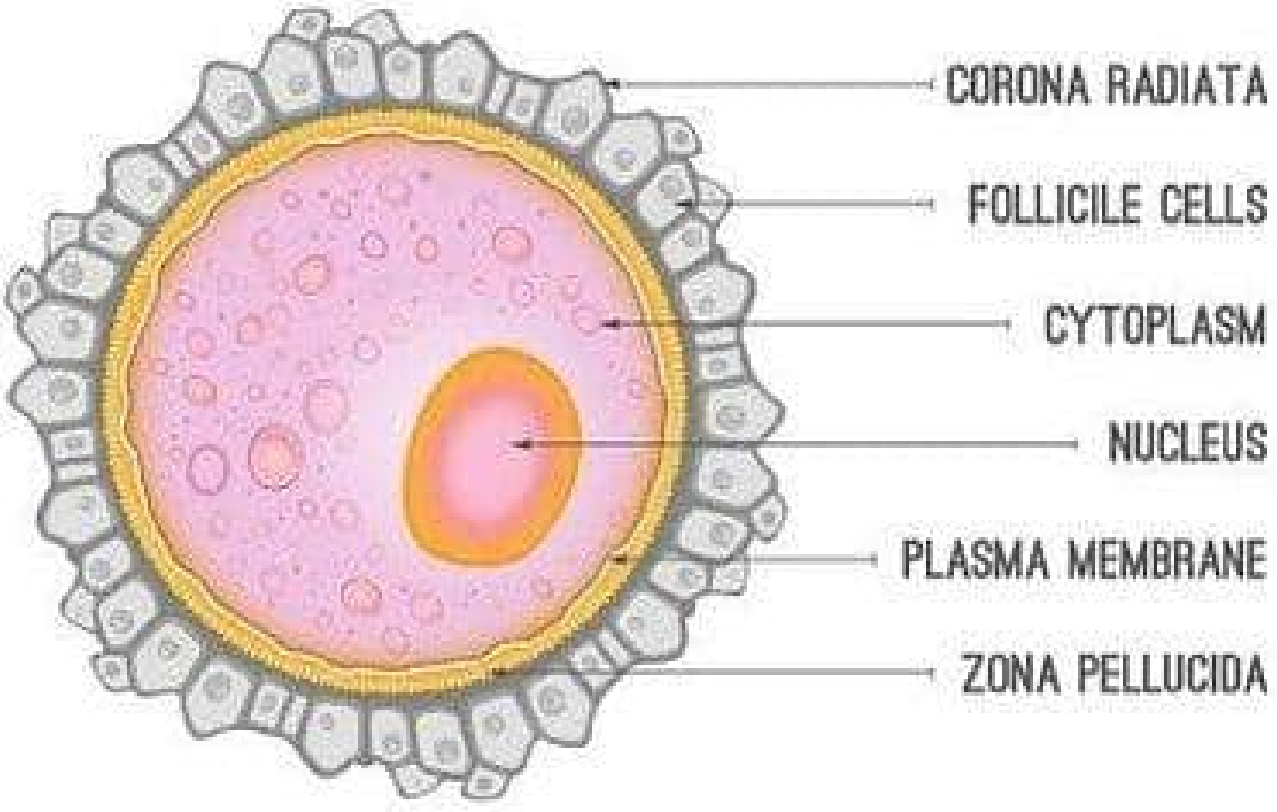
Structure of the Ovum

The female gamete or ovum is about 0.2mm in diameter. They are much larger than the sperm. It consists of cytoplasm, a central nucleus, granules, and yolk droplets.

The yolk serves as a food reserve for the embryo during its early stages of development. The cytoplasm of the ovum is surrounded by two membranes; the outer vitelline membrane and the inner plasma membrane. In mammals, the outer vitelline membrane is called the Zona Pellucida. This structure helps the sperm to enter the egg through its hard outer layers.

The ovum is surrounded by a jelly coat made up of glycoprotein. The nucleus of the ovum contains chromosomes that carry the genes.

The corona radiata surrounds an egg and consists of two or three layers of cells from the follicle. They are attached to the zona pellucida – the outer protective layer of the egg – and their main purpose is to supply vital proteins to the cell.



REPRODUCTIVE SYSTEM IN VERTEBRATES III

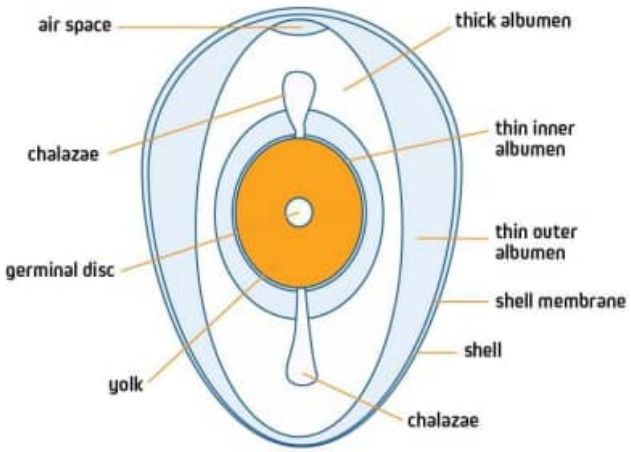
(COMPARISON OF REPRODUCTION IN VERTEBRATES)

Differences Between the Sperm and the Egg

Sperm	Egg (Ovum)
Motile	Non motile
The cytoplasm is small	The cytoplasm is large
Food reserve(yolk) absent	Yolk present
Presence of tail /flagellum	Absence of tail flagellum
Presence of head	Absence of head
Vitelline membrane absent	Vitelline membrane present

Structural Differences Between the Egg of an Amphibian and that of a Bird

Amphibian Egg	Bird's Egg
Yolk and the albumen not surrounded by any membrane.	Yolk and albumen surrounded by membrane.
Yolk not surrounded by chalazae.	Yolk suspended by chalazae.
Egg covered by a flexible layer of jelly.	Egg covered with a calcareous and brittle shell.
No air space in the egg.	Air space present in the egg.



Structure of a Bird'd egg

Differences Between the Male Reproductive System & Female Reproductive System

Male Reproductive system	Female Reproductive system
Testes are present	Testes are absent
Seminal vesicle is present	Seminal vesicle is absent
Penis is present	Penis is absent
Presence of sperm duct	Sperm duct is absent
Cowper's gland is present	Cowper's gland is absent
Prostate gland is present	Prostate gland is absent
Vagina is absent	Vagina is present
Ovaries are absent	Ovaries are present
Clitoris is absent	Clitoris is present
Vagina is absent	Vagina is present
Uterus is absent	Uterus is present
Testes are located outside the abdominal cavity.	Ovaries are located inside the abdominal cavity

Comparison of Reproduction Among Vertebrates

Vertebrates	Fish	Amphibian	Reptiles	Birds	Mammals
No of eggs laid	Very many	Many	Few	Few	Few
Fertilization	External	External	Internal	Internal	internal
Nourishment of embryo	From albumen and yolk	From albumen and yolk	From albumen and yolk	From albumen and yolk	From placenta of mother
Yolk	Moderate	Moderate	Very large	Very large	Small
Parental care	Present in some species	Absent	Absent	Occurs for a short period	Present and remains for a long time
Metamorphosis	None	Present	None	None	None
Mode of zygote growth	Oviparous	Oviparous	Oviparous	Oviparous	Viviparous
Breeding time	seasonal	seasonal	seasonal	seasonal	Seasonal in mammals except human beings

REPRODUCTIVE SYSTEM IN PLANTS

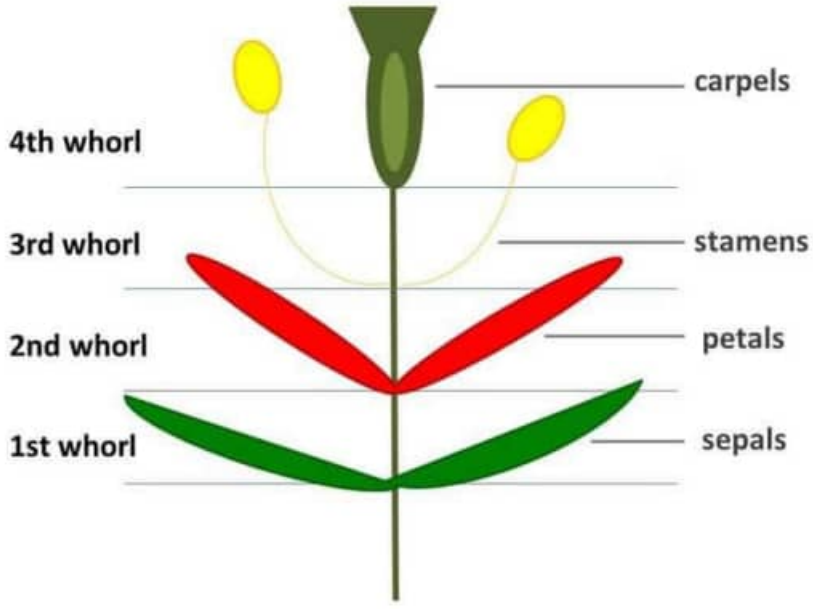
Reproductive System in Flowering Plants

Meaning of Reproduction

Reproduction is the process that brings forth new organisms of the same kind with their parents. Offspring are produced by the process of reproduction. The flowers are the sexual parts of a flowering plant. They contain the sexual organs in which the gametes are produced.

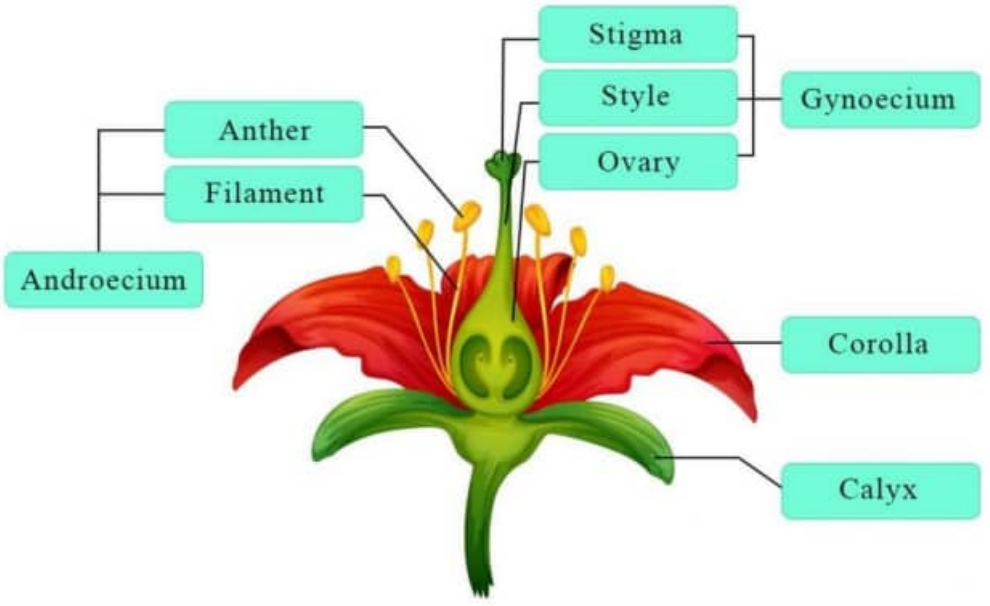
The Structure of a Flower

The flower is a part of the shoot modified for sexual reproduction. It develops on the receptacle, which is the flattened tip of the flower stalk or pedicel. The floral parts are arranged in circles or whorls and there may be up to four whorls.



Starting from the outside, these whorls are

1. The calyx made up of sepals
2. The corolla made up of petals
3. The Androecium made up of stamens
4. The Gynoecium made up of carpels



The Calyx

In most flowers the calyx covers and protects the inner whorls during the bud stage.

The sepals are usually green in colour, but in some plants, they are of the same colour as the petals and are described as petaloid e.g. *Allamanda,* or fused or partly joined together e.g. Hibiscus. Epicalyx refers to any floral whorl found outside the calyx

Functions

1. It protects the inner parts of the flower at the bud stage
2. Attracts insects for pollination If brightly coloured and if green, helps to manufacture food.

The Corolla

The corolla, made up of **petals** lies inside the calyx. They are usually the most conspicuous part of the flower. In some flowers, the petals are scented e.g. coffee, frangipani.

Petals may be either free and are described as polypetalous e.g. Hibiscus or may be fused (wholly or partly joined together) and are described as gamopetalous e.g. Allamanda. Petals help in protecting the inner parts (reproductive organs) of the flower and attract insects for pollination.

The parts of the two outer whorls may look alike and are called perianth segments e.g *Glorissa.*

Functions

1. Attracts insects for pollination if brightly coloured
2. They provide a landing platform for insects during pollination

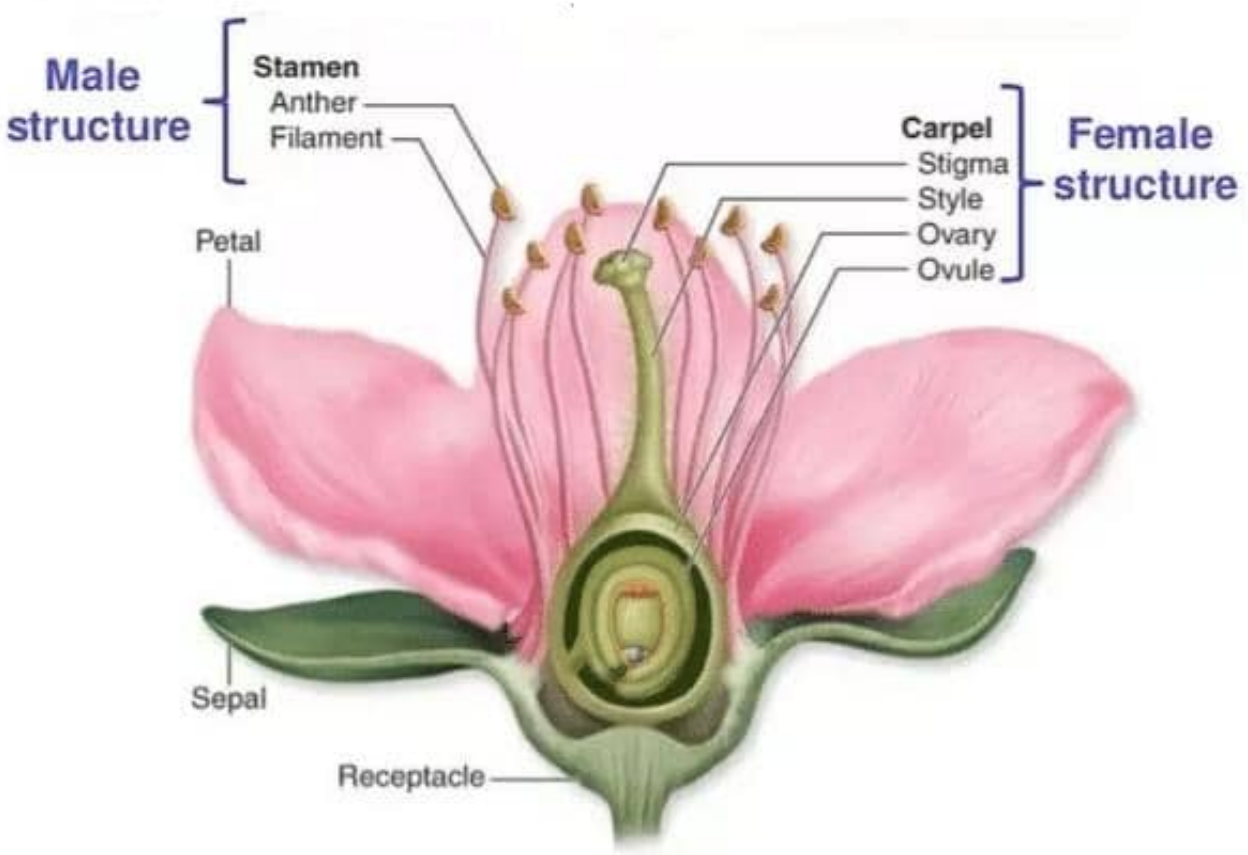
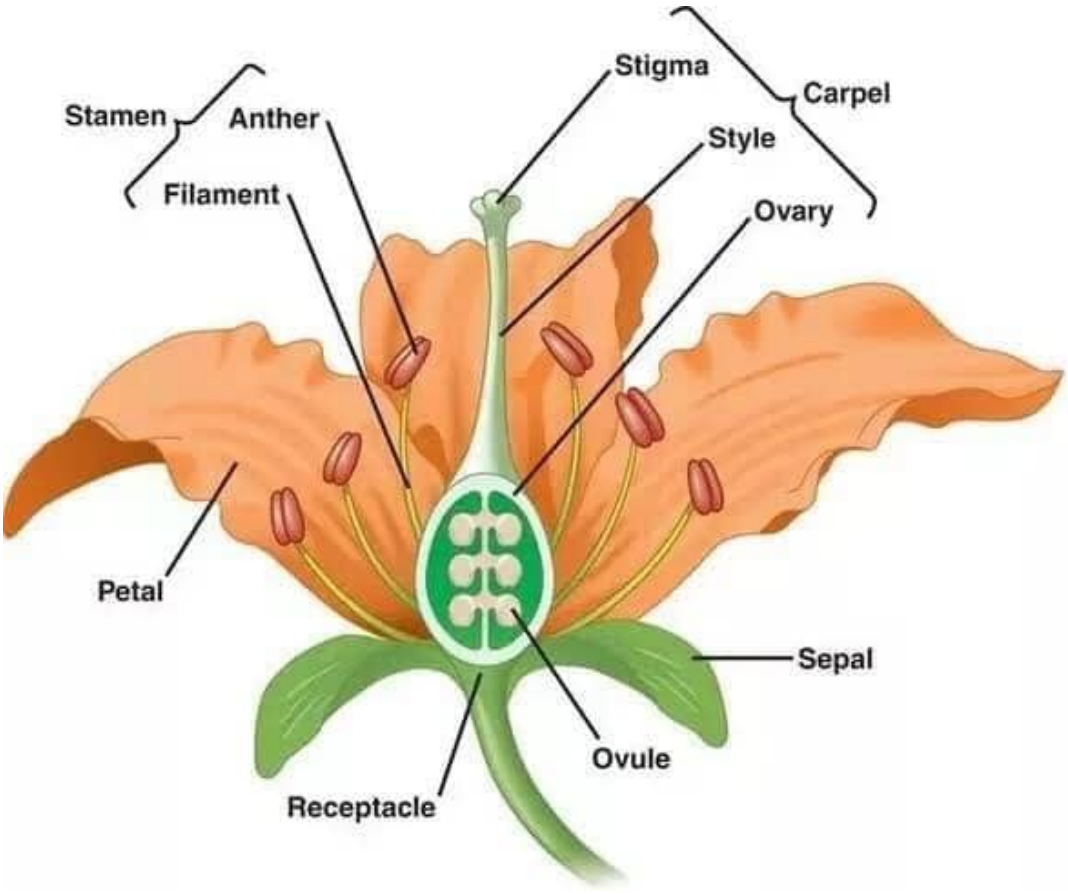


Diagram showing parts of a flower



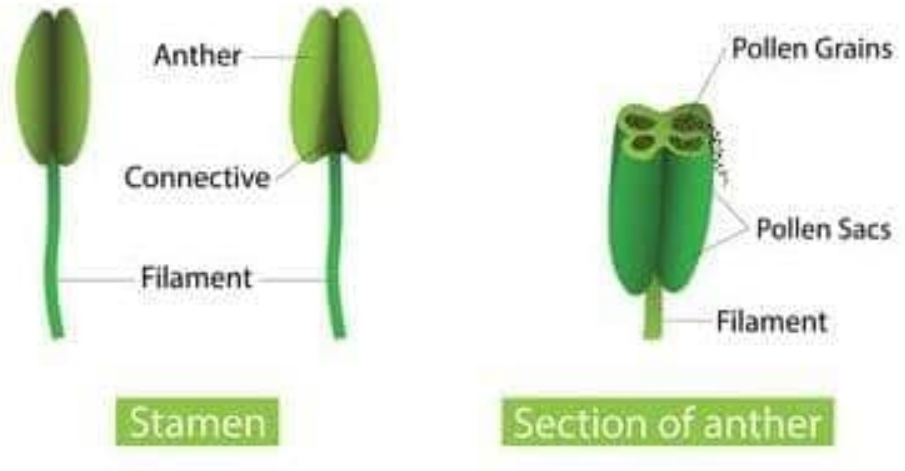
Androecium

The androecium is the collective name for the stamen which produces the pollen grains. The stamen is the male part of the flower.

A typical stamen consists of

1. The anther
2. The filament

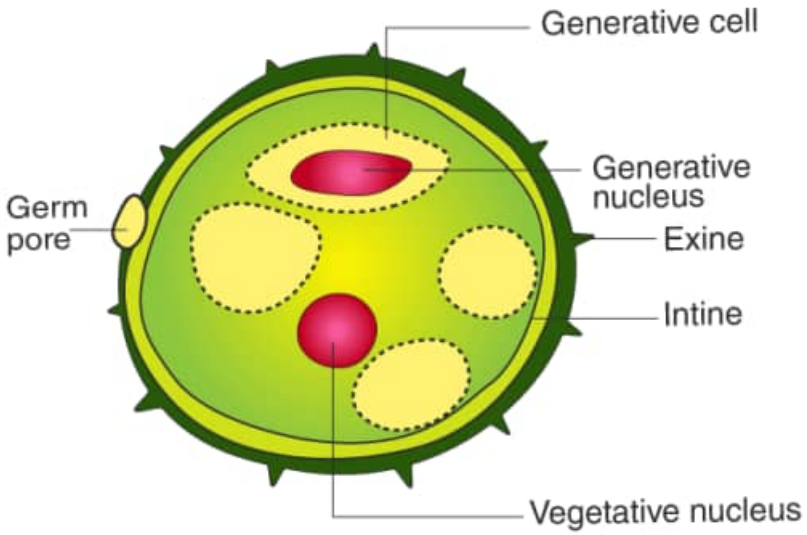
The anther consists of two lobes each containing two pollen sacs. The pollen grains are contained in the pollen sacs. Hibiscus has an unusual androecium. It has many stamens but their filaments are fused to form a tube around the styles.



Structure of Anther

The pollen grains are fine yellowish particles of different shapes and sizes inside the another.

Each pollen grain is composed of two coats; a tough protective outer coat called exine and a thin inner coat called intine of cellulose.



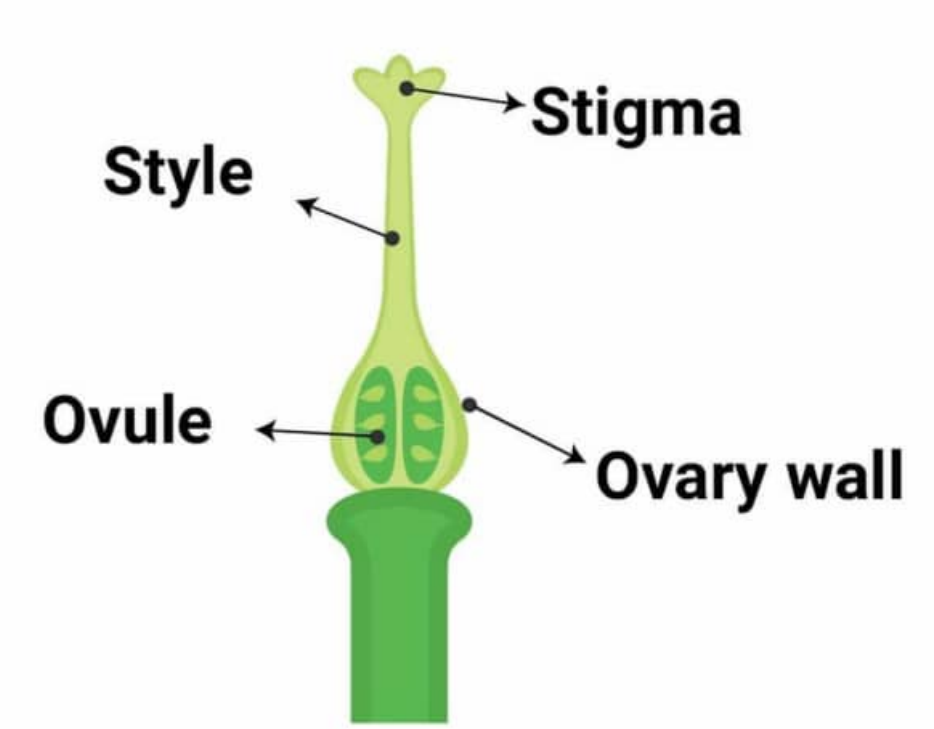
Structure of pollen grain

Gynoecium

The gynoecium or pistil is the female part of the flower. It is made up of carpels.

A carpel consists of three parts

1. The ovary, containing the/ova or female gametes.
2. The style, connecting the ovary to the stigma.
3. The stigma, which receives the pollen grains.



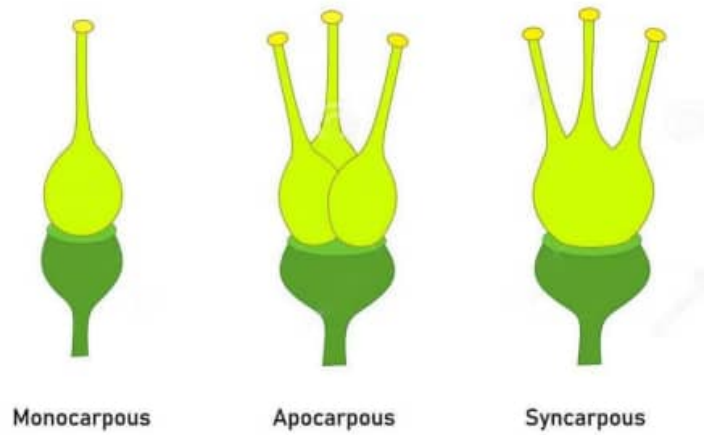
Structure of Carpel

There are different types of carpels;

(a) **Monocarpous pistil:** A pistil with only one carpel e.g. flamboyant flower

(b) **Apocarpous pistil:** A pistil with several free carpels. Here the carpels remain entirely separate from one another e.g. Rose flower, *Bryophyllum*.

(c) **Syncarpous pistil:** All the carpels or at least their ovaries are fused, for example, in Hibiscus, the ovaries and styles are fused but the stigmas remain separate.



Types of Ovary

In many flowers, the pistil rests on the receptacle with other floral parts inserted below the ovary.

An ovary can be described as superior, inferior, and half inferior depending on the position of the pistil in relation to other floral parts.

i. Superior Ovary

An ovary is described as superior when it is placed above other floral parts such as the calyx, corolla, stamens on the receptacle e.g. Hibiscus flower. A flower having this kind of ovary is described as **hypogynous flower** e.g. *Crotalaria, Allamanda, Flamboyant, Hibiscus etc.*

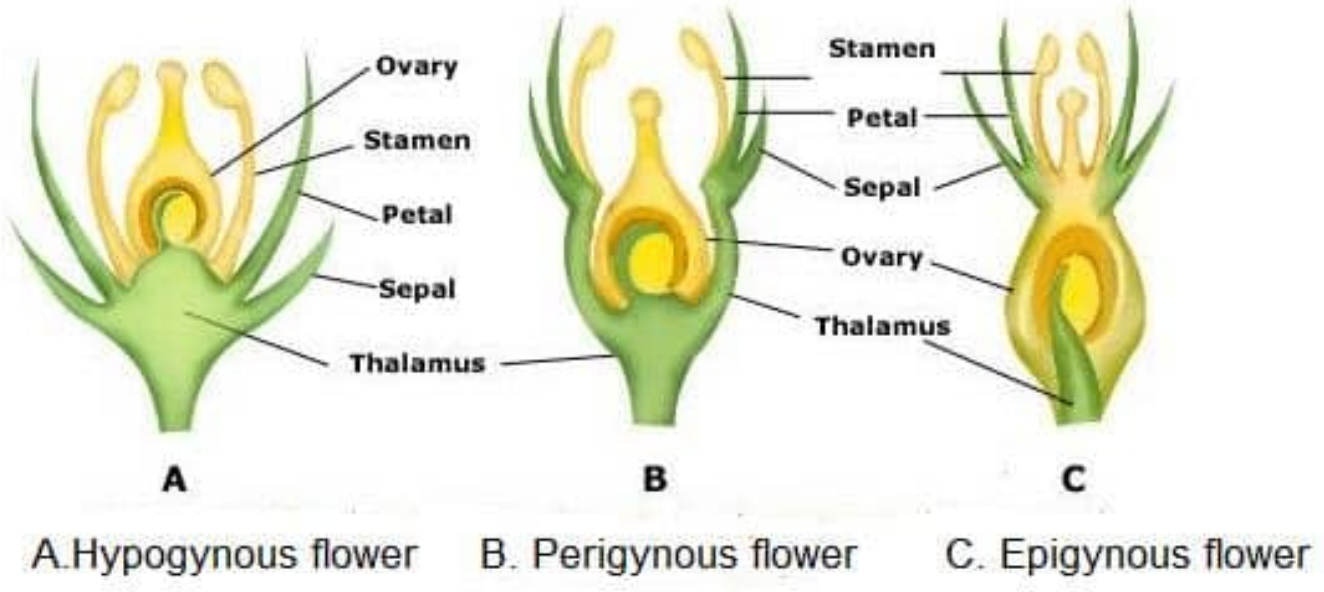
ii. Inferior Ovary

An ovary is described as inferior when the ovary is embedded in a fleshy receptacle with all other floral parts arising from a position above the ovary.

A flower having this kind of ovary is described as **epigynous flower** e.g *Ixora, Tridax, Emilia, sunflower, Apple etc.*

iii. Half Inferior Ovary

An ovary is described as half inferior when the ovary lies inside a cup-shaped receptacle and other floral parts arise slightly above it or almost at the same level as the ovary. The flower having this kind of ovary is described as a **perigynous flower** e.g. *Rose flower.*



A.Hypogynous flower B. Perigynous flower C. Epigynous flower

Placentation in Flowers

Placentation refers to the arrangement or the position of ovules in the ovary. The ovules are found in chambers called loculi (sing. loculus) which may be separated from one another by partitions known as septa. The ovules in the chambers are attached to the placenta which can be found at the centre of the ovary or along the ovary wall.

An ovule is attached to the placenta by a short stalk called the funicle.

Types of Placentation

There are different types of placentation. These are marginal, axile, parietal, free-central, basal, and apical placentation.

1. **Marginal Placentation:** In this type of placentation, the ovules are attached to the inside margin of the ovary wall. Marginal placentation is common in legumes such as *Crotalaria*. It can also be found in apocarpous ovaries.
2. **Axile Placentation:** Axile placentation is found in syncarpous ovaries where two or more carpels are fused. The ovaries meet in the centre to form the placenta to which the ovules are attached, e.g. Tomato, Orange, Pepper.
3. **Parietal Placentation:** In this arrangement, the ovules are arranged along the inner walls of the ovary. Parietal placentation is found only in syncarpous ovary.

Unlike axile placentation, the placenta is attached to the side walls of the ovary. Only one loculus is present and septum is absent.

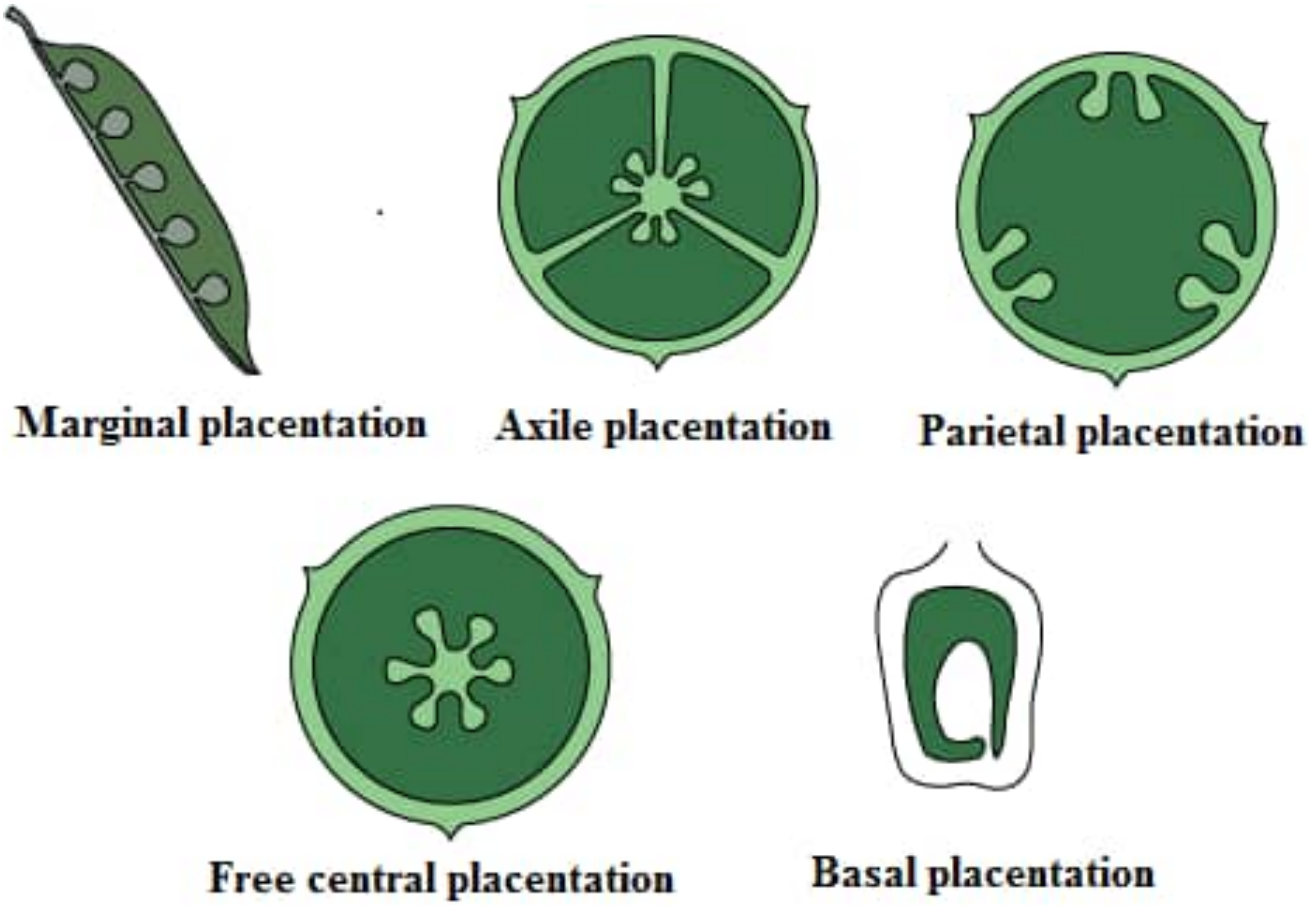
Examples of fruits that display parietal placentation include Pawpaw, Melon, Cucumber.

4. **Free-Central Placentation:** In this type of placentation, the ovules are attached to a central column i.e. to a knob which projects from the base of the ovary. Here the fused carpels have lost their inner walls and there is only one loculus and no septum.

Free – central placentation is found in fruits such as coconut, waterleaf.

5. **Basal and Apical Placentation**: When a single ovule develops at the apex or the base of the ovary, it is known as apical placentation or Basal if the ovules are attached to the base or apex of a syncarpous ovary.

Flowers of the combretum shows apical placentation while those of sunflower show basal placentation.



Placentation

POLLINATION IN PLANTS

Pollination in Plants

Pollination is the transfer of mature pollen grains from the anther to the stigma of flowers. An agent is needed to bring it to pass. Insects, animals and winds are common pollinators, though some flowers with long corolla tubes are self-pollinated.

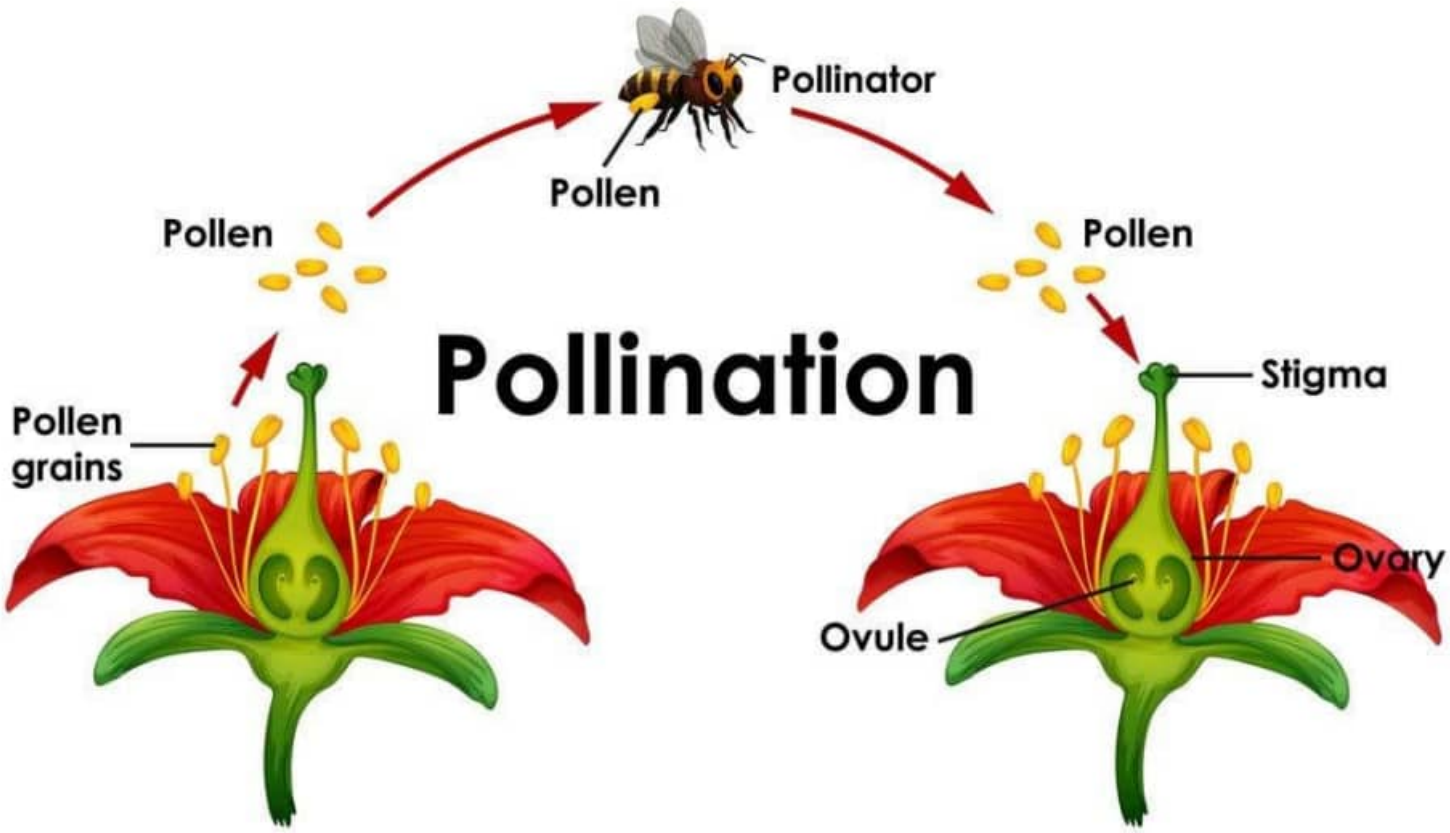


Diagram showing pollination with flower and bee

Types of Pollination

There are two types of pollination

1. Self-pollination
2. Cross-pollination

Self-pollination is the transfer of pollen grains from the anthers to the stigma of one flower or to another flower of the same plant.

Cross-Pollination

Cross-pollination is the transfer of mature pollen grains from the anther of a flower to the stigma of another flower of another plant of the same species, the emphasis is on the same species for instance pollen grains may be transferred from a pawpaw flower to a mango flower. This transfer cannot be described as cross-pollination since both are not of the same species.

Advantages of Cross-Pollination

Cross-pollination is preferable to self-pollination because

(i) The products (seeds, offspring) of cross-pollination are more virile than those of self–pollination (hybrid vigour)

(ii) In cross-pollination, genes from two parents combine to give rise to a new genetic composition. When parents produce offspring, which have different gene composition some of the offspring may have better survival qualities than their parents

Disadvantages of Cross-Pollination

1. It is less certain to occur since it involves two separate plants which may be at a great distance apart.
2. Pollen grains are more likely to be wasted during the process as pollination agents may be transferring them to wrong plants or different species.
3. Cross-pollinated flowers are often more complicated in structure and require special mechanism than self-pollinated flowers

Arrangement of Flowers that Favour Cross-Pollination

1. **Unisexuality:** Male and female flowers are separate and borne on different plants. Such flowers are unisexual and the plants are called dioecious plants e.g. pawpaw
2. Male and female flowers are separate and on the same plant, but the flowers ripen at different times e.g. maize The flowers are unisexual but the plant is said to be monoecious

3. Dichogamy: Male and female parts are in one flower but ripen at different times. This condition is referred to as dichogamy.

If the anther ripens before the stigma the flower is protandrous, but if the stigma ripens before the anther, the flower is described as protogynous.

4. Self-sterility of incompatibility: The female part of a flower is sterile with respect to the pollen grains of the same flowers e.g tobacco, and many legumes.

5. The stigma is located above the anther of the same flower e.g Thumbergia.

Self-Pollination

Self-pollination occurs when the pollen from the anther is deposited on the stigma of the same flower, or another flower on the same plant.

Advantages of Self-Pollination

1. Self-pollinated flowers produce pollen grains in small quantities
2. Pollination is more certain to occur as it does not involve distance once the pollen grains are mature.

Disadvantages of Self-Pollination

1. Seeds produced are less healthy than seeds produced by cross pollination
2. Little or no variation exists among species, and the rate of evolution is slower
3. Plants produced from self-pollination are less likely to survive when there are changes in the environmental conditions

Features of Self-Pollinated Flowers

1. Homogamy: Their anthers and stigma's ripen at the same time in a hermaphrodite flower
2. The stigma is at the same level and is surrounded by the anther
3. The stigma lies below the anthers and is positioned in a such a way that visiting insects can brush the pollen grains into the stigma
4. The stigmas, usually above the anther, bends backward to touch the pollen grains when cross-pollination fails as in the sunflower
5. The corolla encloses the stamen and stigma and does not open fully so that it is possible for the corolla to bring the anthers and stigma together.

Conditions that Favour Self-Pollination

1. **Cleistogamy:** Cleistogamous flowers never open at all. This ensures that pollination occurs within the flower. The flowers are usually bisexual, small, and inconspicuous. Cleistogamy is a characteristic of many legumes and groundnut.
2. Homogamous flowers are bisexual. The anthers and the stigma mature at the same time to increase the chances of self-pollination. The anthers and stigma are brought into close contact by the curving or bending of the filaments and style, examples of Homogamous flowers include mirabilis and Ixora.

Agents of Pollination

These are insects and other organism that bring about pollination. They include

1. Insects
2. Water
3. Wind
4. Animals

Insect Pollinated Flowers / Entomophilous Flowers

Characteristics

1. The flowers are very conspicuous with large and brightly coloured petals
2. The flowers are often scented to attract insects and other pollinatotrs
3. Flowers possess nectaries which secrete nectar or flower juice
4. The anther produced few pollen grains
5. The pollen grains produced are rough spiny or sticky so as to stick to the body of insects and other agents of pollination such as animals
6. Examples of insect-pollinated flowers include *Hibiscus, Pride of Barbados flower, Delonix, Allamanda, Crotalaria, Flamboyant.*

Wind Pollinated or Anemophilous Flowers

Characteristics

1. They are often inconspicuous and not brightly coloured.
2. They do not possess scent.
3. They do not possess nectaries.
4. Calyx and corolla are reduced to perianth segment or sometimes absent.
5. They produce large qualities of pollen grains.
6. Pollen grains are usually small, light and not sticky.
7. Anthers are positioned in such a way that they readily swing in the air to release the pollen grain.
8. The stigma are large and feathery with sticky surfaces to retain any pollen grain that lands on it.
9. Examples of wind pollinated flowers include rice, millet, wheat and the flowers of the cereals.