Science Notes Part 51 to 55

51] Human Body Organ System

INTRODUCTION:

There are ten major organ systems in our body that work together and ensure that we can perform all our functions.

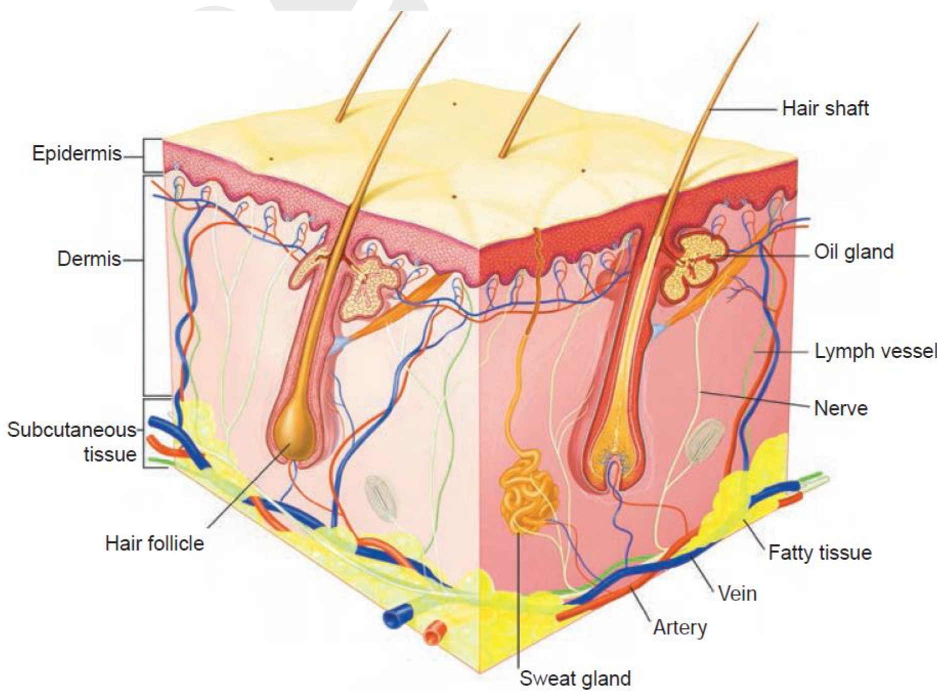
Human Body Organ Systems	
Integumentary system	Circulatory system
Skeletal system	Nervous system
Digestive system	Respiratory system
Reproductive system	Urinary system
Muscular system	Endocrine system

INTEGUMENTARY SYSTEM

Skin, nail and hair form parts of the integumentary system. Skin is exposed to changes in the environment, physical injuries and continuous attacks from micro-organisms. These functions are effectively monitored and carried out with the help of skin appendages like the hair on the head, body hair, nails, sweat glands and sebaceous glands.

2.1 SKIN

The skin is highly essential to protect internal organs and to prevent the entry of pathogens into the body.



Structure of skin

The skin is like an envelope and its complex structure is divided into three layers of tissues: 1. Epidermis 2. Dermis 3. Hypodermis

1. Epidermis

Epidermis is the upper layer of the skin. The outermost layer consists of flat, thin and scale - like dead cells. It is separated from the dermis by the basement membrane. The epidermis contains melanocytes and gives colour to the skin. The deepest layers of epidermis have nerve endings.

2. Dermis

The dermis is the middle layer. It is thick but elastic. The dermis consists of nerves, blood vessels, hair follicles, sweat glands and sebaceous glands (oil glands). Sweat glands separate sweat from the blood. Sweat glands also help in thermoregulation by cooling the surface of the skin to maintain body temperature. It brings about excretion by eliminating excess water and dissolved salts from the body. It also provides protection from colonization by bacteria and entry of pathogens through the skin surface. Sebaceous glands secrete sebum which keeps the skin smooth and shiny. The arrector pili is the smooth muscle necessary to move the hair.

Wrinkles: If you pinch your skin and let go, it springs back into shape. This happens because the skin contains proteins in the dermis that stretch like elastic. As people get older, their skin becomes less elastic and so it begins to form wrinkles.

3. Hypodermis

It is the innermost layer of the skin. It is thick and contains large amounts of adipose tissue. The adipose tissue stores fat and reserves energy. It provides the body with insulation.

Functions of Skin

1. The skin protects the internal organs of our body.
2. It prevents the entry of infectious agents.
3. It reduces water loss.
4. The skin regulates the body temperature.
5. The skin can prepare Vitamin D with the help of sunlight.
6. It helps us to feel touch, pain and temperature.
7. The skin acts as an excretory organ and excretes sweat.

2.2 MUSCULAR SYSTEM

This system is made up of muscles that helps the body to move. Muscle tissue is made of bundles of cells and fibres that work in a simple way. They can contract and relax.

The skin colour of humans is determined by the melanocytes of the basement membrane. The formation of melanocytes is determined by heredity.

The human body consists of about 700 different muscles. Based on their structure, function and position, they can be divided into skeletal, visceral and cardiac muscles.

Various animals and their locomotory organs

Animals	Locomotory organs
Amoeba	Pseudopodia
Paramecium	Cilia
Euglena	Flagella
Earthworm	Body setae
Star fish	Tube feet
Fish	Fins
Birds	Wings
Bat	Patagium

Skeletal Muscles

The skeletal muscles are those that are controlled consciously. It includes bones of hands and legs, among others. The function of the skeletal muscle is to move parts of the body closer to the bone to which the muscle is attached. Every skeletal muscle is attached to bones by tendons. These muscles are covered by sheets of connective tissues called fascia.

Tendons

These are connective tissue structures showing slight elasticity. They are like cords or straps, attached strongly to bones. The tensile strength of tendons is nearly that of steel. A tendon having 10 mm diameter can support 600 – 1000 kg.

Fascia

Fascia is a sheet of connective tissue that forms a lining around skeletal muscles. The fascia may be superficial or deep. The superficial fascia is a layer of loose connective tissue found between the skin and the muscles. The deep fascia are collagen fibres found as a tough, inelastic sheath around the muscle. They run between groups of muscles and connect with the bones.

Distribution of muscles

There are five different sets of muscles in our body:
1. Muscles of the head.
2. Muscles of the neck.
3. Muscles of the trunk region.

4. Muscles of the upper limb.
5. Muscles of the lower limb.

A few muscles and their functions

Facial Expressions

Facial expressions, such as looking, shocked or smiling are tiny voluntary movements made by more than 30 different muscles. Although they are voluntary, we often make these movements without our knowledge.

Breathing

Four important thoracic muscles are associated with the process of breathing. The process of inspiration involves scalene and external intercostal muscles. The expiration is performed by the internal intercostal muscles and the transverse thoracis. The major breathing movement is due to the presence of diaphragm, a curved musculo fibrous sheath that separates the thoracic cavity from the abdominal cavity.

Functions of muscles

1. Muscles are responsible for locomotion.
2. They provide shape to our body.
3. The inner smooth muscles of the visceral organs make them work like a machine throughout our life.

- *Muscles cannot push, they can only pull.*
- *The tongue is one of the most active muscles in our body.*

LUIGI GALVANI

By accident, the Italian professor of Anatomy, Luigi Galvani (1737-98) discovered that a dead frog's legs contract when they are pegged to an iron frame with brass pins. Galvani thought that the frog's muscle movement made electricity, which had caused the contractions. Galvani was right to think that electricity made the muscle move, but in fact it was the two metals acting together that formed the electricity. We now know that in living animals, electrical signals from the nerve make the muscles contract

1 sq.cm. of muscle can lift 3.5 kg. of weight.

Significant muscles, their location and movement:

S.No.	Name	Location	Movement

1	Trapezius	Upper back and each side of neck	Upper pulling movement
2	Deltoids	Shoulders	Arm raising
3	Pectorals	Chest	Horizontal pressing and drawing of arm across the body
4	Lattismus dorsi	Wide back muscle	Pulling and rowing movement
5	Biceps	Front portion of the upper arm	Arm bending and twisting
6	Triceps	Back of upper arm	Pushing and straightening of upper arm.
7	Calves	Lower leg between ankle and knee	Raising and lowering of toes.

2.3 SKELETAL SYSTEM

The skeletal system gives shape and form to our bodies. It supports and protects our bodies and helps to bring about movement, produce blood cells and store minerals. This system includes bones, cartilages and joints.

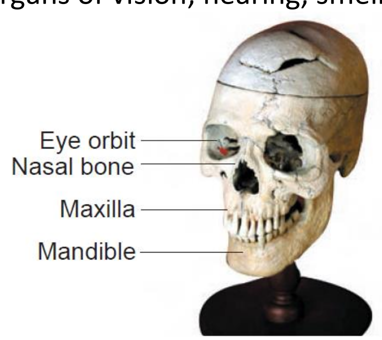
The bones can be long, short, flat or irregular in shape. The human skeletal system is divided into two parts:
1. The axial skeleton
2. The appendicular skeleton.

Axial Skeleton

It is the upright axis of the body. Axial skeleton consists of the skull, the hyoid bones, the vertebral column and the thoracic cage.

Skull

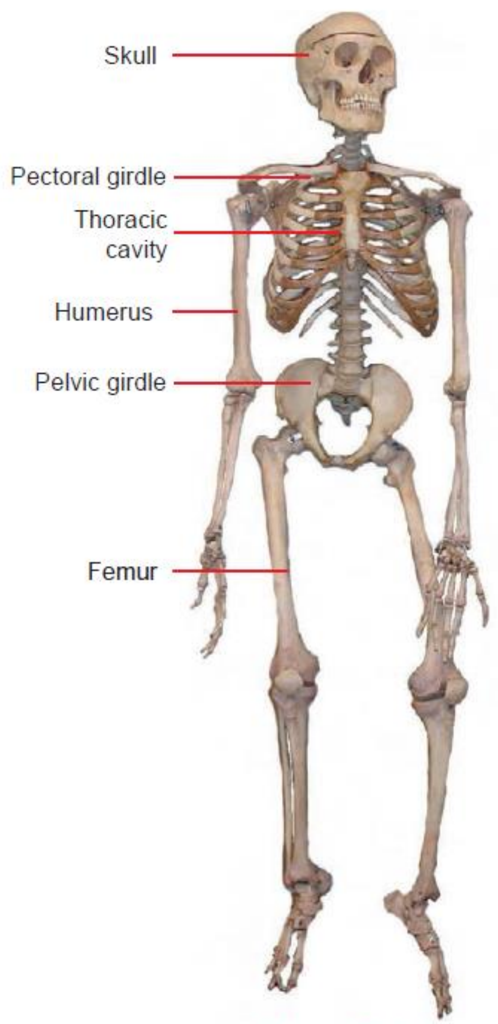
The human skull consists of 22 bones: 8 bones form the cranium and the remaining 14 are facial bones. The bones of the cranium are flat. They are connected by immovable joints. Cranium protects the brain. The skull also supports the organs of vision, hearing, smell and taste.



Human Skull

A large opening is found at the base of the skull. Through this opening, the medulla oblongata of the brain descends down as the spinal cord.

- Phylum mollusca is the animal group that does not have internal skeletal system.

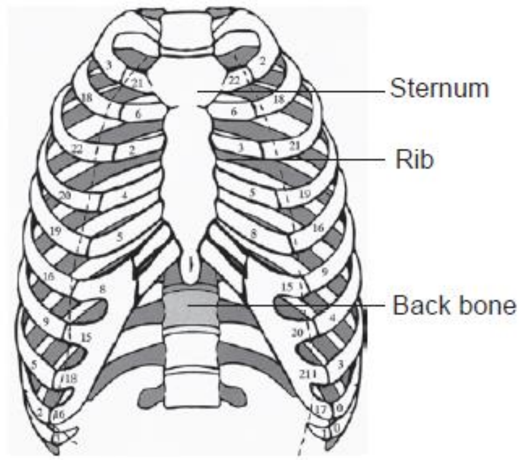


Human Skeleton

Thoracic cage

The thoracic cage or rib cage is made up of ribs that are attached to a long flat bone in front of the chest called the sternum. The ribs are also connected behind the thoracic region of the vertebral column.
This thoracic cage encloses a space called the thoracic cavity. The thoracic cage protects the heart and the lungs that are located inside the thoracic cavity.

There are 12 pairs of ribs. Each pair articulates with a thoracic vertebra. In the front, the first ten pairs are attached to the sternum. The first seven pairs are directly attached to the sternum. They are called the true ribs. The cartilages of the 8th, 9th and 10th are fused and attached to the sternum indirectly. They are called false ribs. The 11th and 12th pairs are not attached to the sternum. They are called floating ribs.

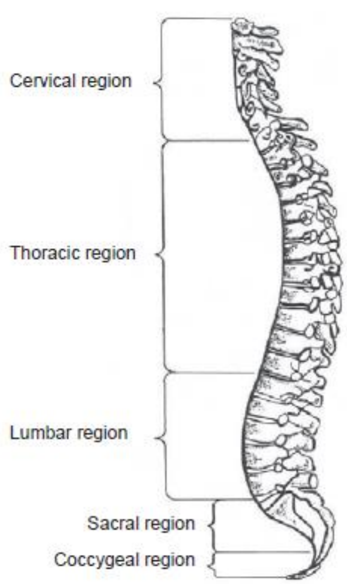


Thoracic cavity of a human

The vertebral column or Spine

The vertebral column has a natural S-shaped curve. It helps to support the weight of the body. The vertebral column consists of 33 vertebrae that can be

> All vertebrates have the ability to move only their lower jaw. Interestingly, the crocodile can keep its lower jaw still and slam down with its upper jaw.



vertebral column of a human

grouped into five sets based on their location. They are:
1. Cervical vertebrae - 7
2. Thoracic vertebrae -12
3. Lumbar vertebrae - 5
4. Sacral vertebrae - 5
5. Coccygeal vertebrae - 4

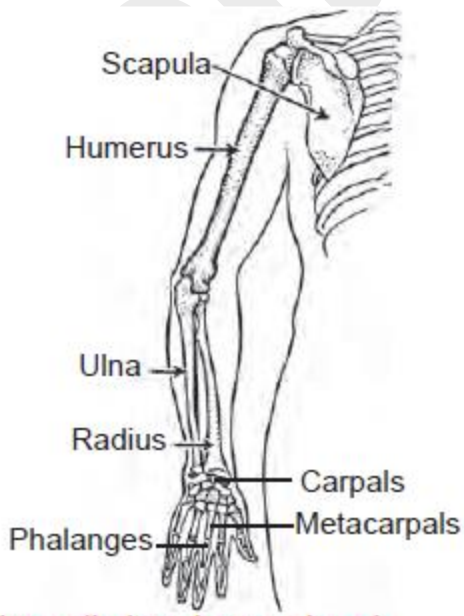
The five sacral bones are joined together to form one bone called the sacrum. The four coccygeal bones are fused together to form another bone called the coccyx. So the total number of vertebrae add up to only 26.

Appendicular skeleton

The appendicular skeleton consists of the pectoral girdle and the upper limb (hand), the pelvic girdle and the lower limb (leg).

Upper limb or hand

The hands are attached to the pectoral girdle. Each pectoral girdle has a pair of scapula or shoulder blade and a clavicle or collar bone.



Upper limb or human hand

The glenoid fossa is located in the superior lateral region of the scapula. It articulates with the head of the humerus.

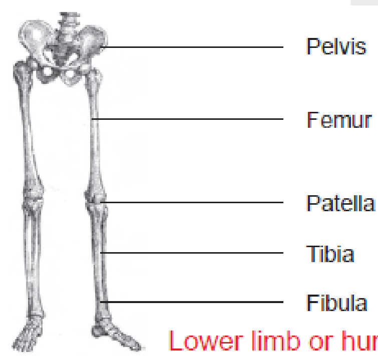
The upper arm has a long bone called humerus. The distal end of the upper arm articulates with the two forearm bones named ulna and radius. The wrist consists of eight carpals, arranged in two rows. The framework of the palm is formed of five metacarpals. Each palm has five digits. They include one thumb and four fingers. Each digit is made up of long small bones called phalanges. The thumb has two phalanges and each finger has three phalanges.

The pelvic girdle and the leg

The pelvic girdle is a ring of bones in the hip region formed by sacrum and paired bones called coxae or hip bones.

A fossa called the acetabulum is located on the lateral surface of the hip bones. It is meant for the articulation of the lower limbs.

Each coxa is formed by the fusion of three bones namely ilium, ischium and pubis. The thigh region contains the longest bone called the femur. The distal end of the femur has connection with tibia and fibula. The knee region has a large flat bone called the patella.



Lower limb or human leg

The ankle consists of seven tarsal bones. The ankle articulates with tibia and fibula at the talus. The foot is formed by metatarsals and phalanges. They correspond to the metacarpals and phalanges of the hand.

Functions of Bones

- Bones provide a framework for the attachment of muscles.
- It helps to hold the weight of our body.
- They support and protect the internal organs.
- This system is useful for locomotion.
- Bones act as a reservoir for calcium and fat.
- The bone marrow is the site for the production of red blood corpuscles.

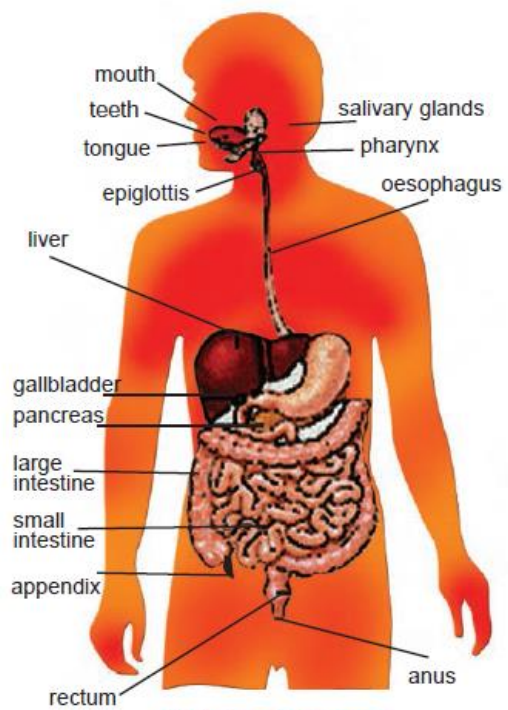
Number of bones in human body

In the human body, there are 206 bones, of which 80 are in the axial skeleton and 126 are in the appendicular skeleton. Among the bones of the axial skeleton, 28 bones are in the skull, 26 bones are in the vertebral column, 25 bones are in the thoracic cage and one remains as the hyoid bone.

2.4 DIGESTIVE SYSTEM

Digestion is the process of conversion of complex compounds like carbohydrates, proteins and fats into simpler molecules like glucose, amino acids, fatty acids and glycerol respectively. These simpler molecules can then be assimilated either by blood or by lymph. The digestive system can be divided into the alimentary canal and the associated glands.

The alimentary canal



Organs of digestion

It is a coiled muscular tube extending from the mouth to the anus. It is about 6-9 meters long and consists of many specialized sections. Arranged sequentially, they are: mouth, buccal cavity, pharynx, oesophagus, stomach, small intestine, large intestine, rectum and anus. It also includes, some accessory digestive organs like salivary glands, pancreas and liver.

Mouth

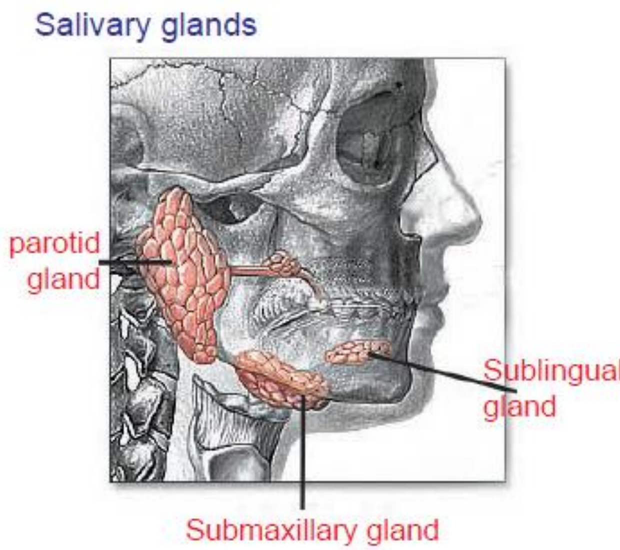
The mouth opens into the buccal cavity. The roof of the cavity is lined by the palate. The floor bears a muscular tongue. The teeth are found on the upper and lower jaws.

Teeth

Adults have 32 teeth, 16 in each jaw which includes 4 incisors, 2 canines, 4 premolars and 6 molars. The last set of molar teeth grows after the age of 20. Hence they are referred to as the wisdom teeth. Each tooth is made up of a bonelike substance called dentine and is covered with a layer of enamel, the hardest substance in the body. Teeth help to cut and grind food to aid in digestion.

Tongue

The tongue is a small muscular organ responsible for the sense of taste. It is attached to the floor of the mouth. The upper surface of the tongue contains several papillae or sensory buds. The tongue helps to push the food and also helps in the process of swallowing.



There are three pairs of salivary glands that open into the mouth. They are the parotid, the submaxillary and the sublingual.

- Parotid glands - They are the largest of the three pairs of glands. They are found below the ears.
- Submaxillary gland - It is found below the jaw and irregular in shape.
- Sublingual gland - It is the smallest gland found at the base of the tongue.

Salivary glands secrete saliva. The saliva has the following:
1. Ptyalin(Amylase) - enzyme
2. Bicarbonate - salt
3. Mucus
4. Lysozyme - enzyme

Pharynx

The pharynx is found below the nose and the mouth. It is about 11 cm in length. This region has 7 openings. They are: 2 internal nostrils, 2 eustachian tubes, mouth, larynx and oesophagus.

Oesophagus

It is a musculo-membranous canal about 22 cm in length. It extends from the pharynx to the stomach. The inner lining has a mucus coat and it is lined by epithelium.

Stomach

The stomach is an important organ of digestion. It is a muscular sac found on the left side of the abdomen. It can be divided into 3 regions: the cardiac, the fundus and the pylorus. The stomach secretes gastric juice. The gastric juice contains the following:

1. Pepsin 2. Renin 3. Hydrochloric acid

Hydrochloric acid is secreted by a special type of cells called oxyntic cells. Hydrochloric acid and digestive enzymes continue the digestion process of food that begin in the mouth.

Small intestine

The stomach opens into the small intestine through the pylorus. The small intestine is a 5 to 7 m long tube coiled like a hose. The inside surface of it is full of many ridges and folds. The small intestine can be divided into three parts:- duodenum, jejunum and ileum.

The hardest part of the human body is the tooth enamel. If our mouth dries due to dehydration, we will find it difficult to speak.

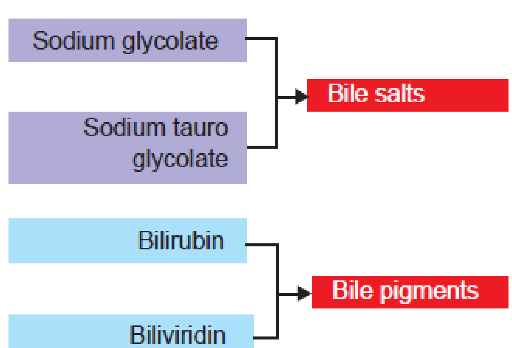
Duodenum

The duodenum is C-shaped and is around 22cms in length.

Liver

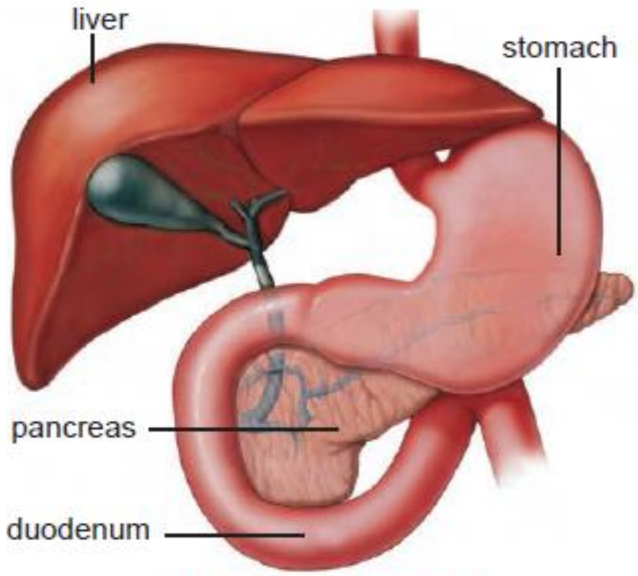
The liver is the largest glandular organ in humans. It weighs about 1500 gms. It contains two unequal lobes. The right lobe is larger than the left. The liver secretes bile juice which is greenish yellow in colour. The bile is temporarily stored in the gall bladder. The gall bladder is attached to the bile duct. The duct opens into the duodenum. Bile juice helps in the digestion of fat. It does not have any enzyme. It has bile salts and bile pigments.

Bile juice



Pancreas

The pancreas is a long, leaf-shaped gland located just below the stomach. The pancreas secretes pancreatic juice.It is connected with the duodenum through the pancreatic duct. The pancreas acts both as an exocrine gland and an endocrine gland. The gland's upper surface bears the islets of Langerhans. The islets of Langerhans are endocrine cells, in which α cells secrete glucagon hormone and β cells secrete insulin.



Liver and Pancreas

As an exocrine gland, it secretes the following enzymes:

1. Trypsin 2. Chymotrypsin 3. Carboxy peptidase 4. Amylase 5. Lipase

Jejunum

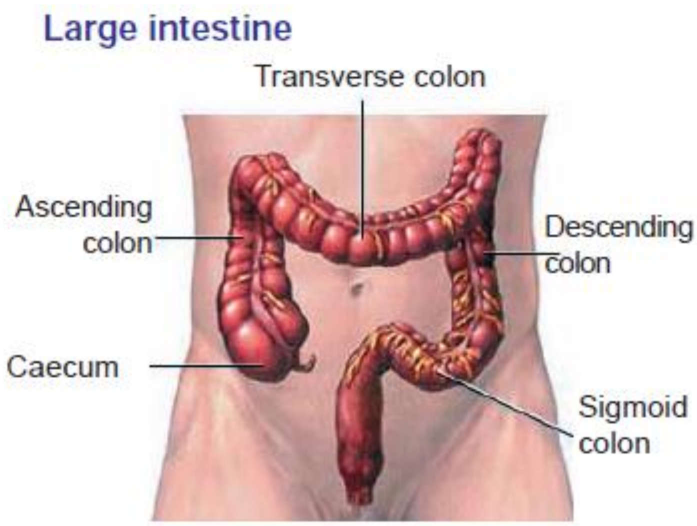
Jejunum constitutes two-fifths of the small intestine. It starts from the duodenum and ends with the ileum. The secretion of the small intestine is intestinal juice. The intestinal juice contains the following enzymes:

1. Sucrase 2. Maltase 3. Lactase 4. Lipase

Ileum

Ileum is a coiled tube-like structure which constitutes three-fifths of the small intestine. It contains numerous minute finger-like projections called villi (1 mm) in length. They are approximately 4 million in number. Internally, each villus contains fine blood capillaries and lacteal tubes where food absorption takes place.

Parotid gland is the only salivary gland affected by mumps virus. The three pairs of salivary glands secrete approximately 1.5 litres of saliva everyday.



Large Intestine

It extends from the ileum to the anus. It is about 1.5 metres in length. It is divided into caecum, colon and rectum.

Caecum

Caecum is a large blind pouch and measures about 5 cm in length. The appendix is located near the junction of the small intestine and the large intestine. It is considered to be a vestigeal organ with no specific function.

Functions of alimentary canal

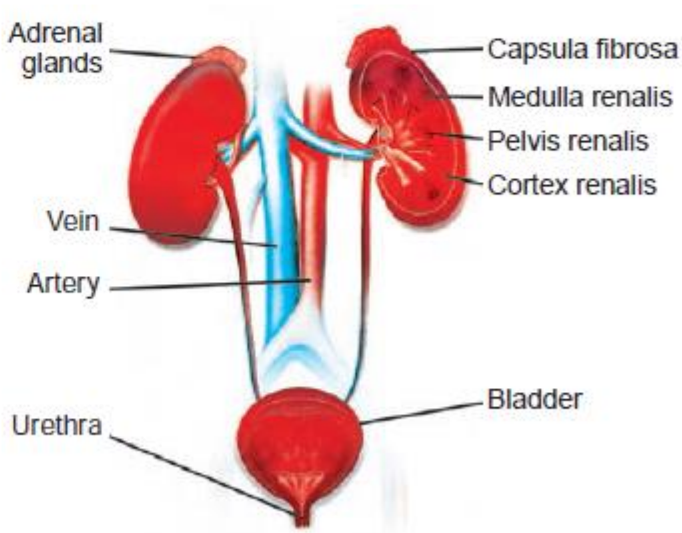
1. Ingestion 2. Digestion 3. Absorption 4. Assimilation 5. Egestion

2.5 EXCRETORY SYSTEM

The excretory system consists of the kidneys, ureters, urinary bladder and urethra. The kidneys filter the blood to remove waste and produce urine.

Kidneys

The kidneys are a pair of dark red, bean-shaped organ placed behind the abdomen on each side of the vertebral column. The average adult kidney measures about 12 cm in length, 6 cm in width and 3 cm in thickness. The outer surface of the kidney is convex and the inner surface is concave and it faces the vertebral column. The right kidney is a little lower than the left kidney because the right side of the body is occupied by the liver. Each kidney is covered by a fibrous membrane called capsule.



Urinary System

The two ureters connect the kidneys with the urinary bladder. It is sac-like in shape and acts as a temporary storage organ of urine. Urine entering the urinary bladder from the ureters slowly fill the hollow space inside the bladder. Urine is expelled from the body through the urethra.

- Eating excess of fatty food leads to the formation of bile stones in the gall bladder.

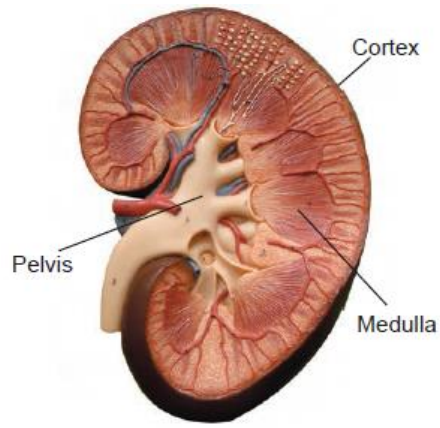
Nephron

The kidneys are made up of millions of nephrons, which are the structural and functional units of the kidneys. Each kidney consists of about one million nephrons.
Kidneys, lungs, liver and skin together function as excretory organs .

Lungs: Lungs excrete CO2 and water from the blood.
Skin : Skin excretes sweat. The sweat consists of dissolved urea, uric acid and lactic acid.
Liver : Liver excretes bile pigments formed during the breakdown of haemoglobin.

Functions of the kidney

1. It excretes nitrogenous waste (urea) formed as a result of protein metabolism.
2. It helps to maintain the fluid and electrolyte balance of our body .
3. It helps to regulate acid-base balance of blood.
4. It helps to maintain osmotic pressure in blood and tissue.
5. It helps to retain important plasma constituents like glucose and amino acids.



Longitudinal section of the Kidney

Kidney functions are the basis of blood pressure.
1. There are approximately 1 million nephrons in each kidney. At least 450,000 of them must remain functional to ensure survival.
2. Every minute, kidneys receive one-fifth of blood of the cardiac output that is approximately 1.250 litres every minute.

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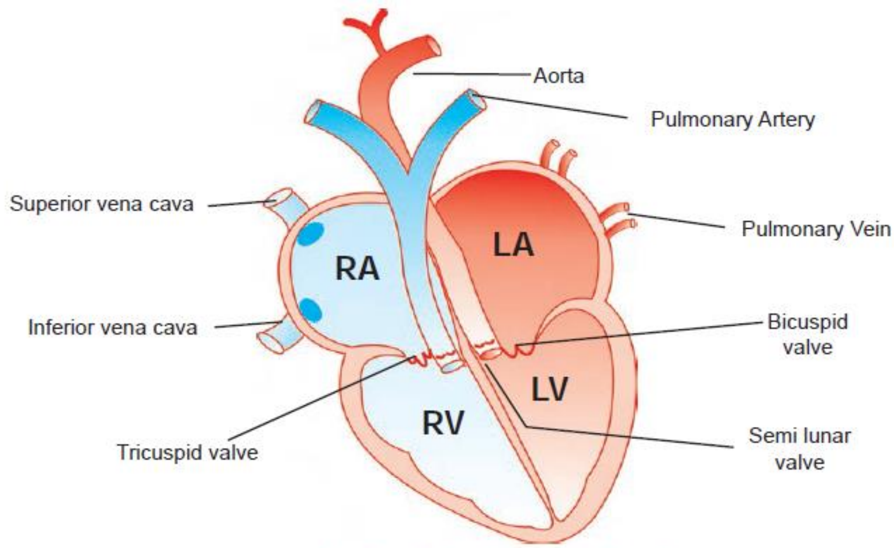
2.6 CIRCULATORY SYSTEM

This system is made up of the heart, blood and blood vessels. It is concerned with circulating blood to deliver oxygen and nutrients to every part of the body.

The heart is a hollow, muscular organ. It is somewhat conical in shape. The heart is covered with double walled membrane called pericardium. The space between the pericardial membrane is called pericardial
space, which is filled with pericardial fluid. The pericardial fluid protects the heart from shock. The heart is placed inside the thoracic chamber in between the two lungs (mediastinum).

Internal structure of the human heart

The heart is a four-chambered muscular organ that pumps blood. The two upper chambers are called atria (singular-atrium) and the two lower thicker chambers called ventricles. The left and right sides of the heart are separated by a muscular wall of tissue known as the auriculo-ventricular septum of the heart. The right side of the heart receives deoxygenated blood from the systemic veins and pumps it to the lungs for oxygenation. The left side of the heart receives oxygenated blood from the lungs and pumps it through the systemic arteries to the tissues of the body.



Longitudinal section of the Heart

Each heartbeat results in the simultaneous pumping of both sides of the heart, making the heart a very efficient pump.

Right Atrium	a) Superior venacava b) Inferior venacava c) Coronary vein
Righ Ventricle	Pulmonary artery (Dexoygenated blood)
Left Atrium	Pulmonary veins (Oxygenated blood)
Left Ventricle	Aorta

Valves in the Heart:

1. Tricuspid Valve: Located inbetween right atrium and right ventricle.
2. Bicuspid Valve(Mitral valve): Lies inbetween left atrium and left ventricle.
3. Semilunar Valves: Present near the mouth of pulmonary artery and aorta.

- Among reptiles, only the crocodile has a four-chambered heart.

Circulation:

The circulation of blood can be divided into two main loops: the pulmonary circulation loop and the systemic circulation loop.

1. Pulmonary circulation transports deoxygenated blood from the right side of the heart to where the blood picks up oxygen and returns to the left side of the heart.

2. Systemic circulation carries highly oxygenated blood from the left side of the heart to all the tissues of the body (with the exception of the lungs). Systemic circulation removes waste from body tissues and returns deoxygenated blood to the right side of the heart.

Blood vessels

Arteries

The blood vessels that carry blood away from the heart are called the arteries. Generally, the arteries carry oxygenated blood, the except the pulmonary artery.

Veins

Generally, the veins carry deoxygenated blood, except the pulmonary veins.

Capillaries

Capillaries are fine, small tubes found like a network of tiny blood vessels inbetween cells. They perform all the functions of the blood vascular system. It is considered as the vital tube of the blood vascular system.

Blood

The average human body contains about 4 to 5 litres of blood. Blood is a liquid connective tissue and it transports many substances through the body and helps to maintain homeostasis of nutrients, waste and gases. Blood is made up of red blood cells, white blood cells, platelets and liquid plasma.

Plasma

It is a non-cellular fluid of about 55% of the blood volume. It is a faint yellow colour fluid, which is alkaline in nature. Plasma contains water, proteins, enzymes, hormones, dissolved elements and waste.

Difference between artery and vein

1	It carries blood from the heart to the organs.	It carries blood from the organs to the heart.
2	It carries oxygenated blood except pulmonary artery.	It carries deoxygenated blood except pulmonary veins.
3	The wall is thick and elastic.	The wall is thin and less elastic.
4	It is found deep inside the muscles.	It is found superficially.
5	Valves are absent.	Valves are present.

Plasma functions as a transport medium for all these substances.

Blood Corpuscles

Nearly 45% volume of blood contains corpuscles. The blood corpuscles are of three types:
1. Erythrocytes or red blood corpuscles (RBC)
2. Leucocytes or white blood corpuscles (WBC)
3. Thrombocytes or blood platelets.

1. Erythrocytes

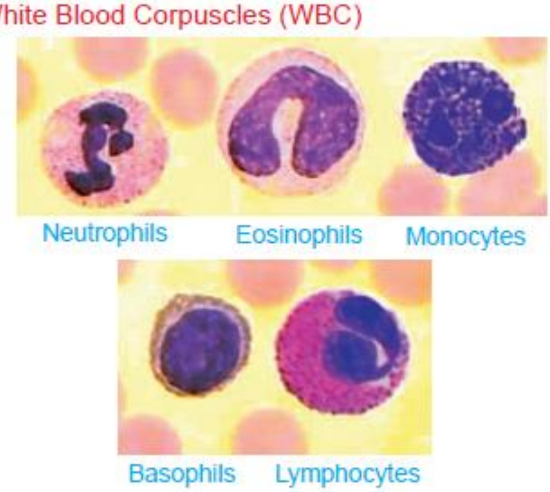
They are red, biconcave and disc shaped cells. The red colour of the RBC is due to the presence of respiratory pigment haemoglobin. Haemoglobin helps in transporting oxygen and carbon-dioxide in our body. One cubic mm of blood contains 5 millions of RBC. They are produced in the bone marrow. The life span of RBC is 120 days. They are destroyed in the liver and the spleen.

Red Blood Corpuscles (RBC)

2. Leucocytes

They are colourless, irregular and nucleated cells. The WBCs are fewer in number when compared to RBCs and they are larger in size. One cubic mm of blood contains 8000 WBCs. There are 5 types of WBC which are monocytes, lymphocytes, neutrophils, eosinophils and basophils. The lifespan of WBC is 4 weeks. They play an important role in the body's immune system.

White Blood Corpuscles (WBC)



WBCs attack the invading germs and protect our body.

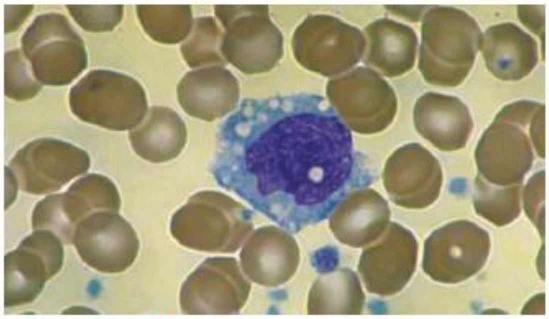
- **72x60x24x365mx80** This is the number of heart beat for a human living up to the age of 80.

3. Thrombocytes (Blood Platelets)

These are small, non-nucleated and colourless structures floating in the plasma. In one cubic mm of blood, there are 2,00,000 to 4,00,000 thrombocytes. Platelets do not contain a nucleus and survive in the body for only up to a week before macrophages capture and digest them. They are responsible for the clotting of blood.

Functions of Blood

1. Blood distributes the digested food.
2. Blood carries the metabolic waste to the excretory organs.
3. Blood carries hormones, which are the secretions of endocrine glands.
4. Blood distributes the heat evenly throughout the body.
5. Blood keeps all the tissues moist.



Blood smear showing
Thrombocytes (Blood Platelets)

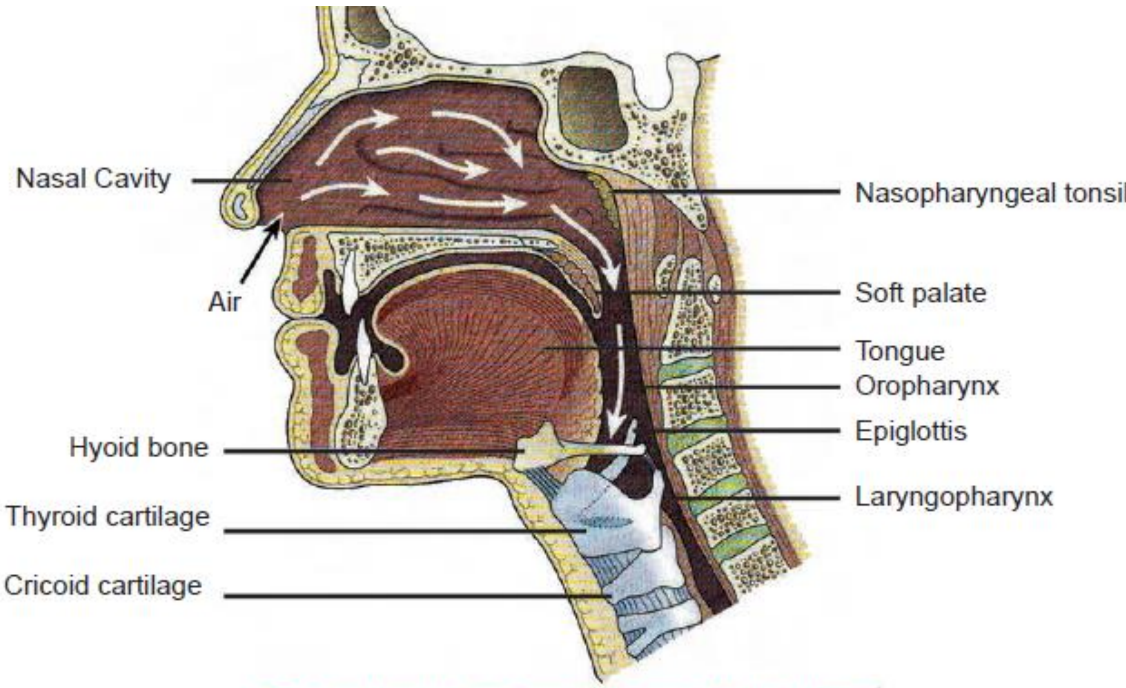
2.7 RESPIRATORY SYSTEM

The respiratory system provides oxygen to the cells of the body, while removing carbondioxide. There are three major parts forming the respiratory system: the airway, the lungs and the muscles of respiration. The airway includes the nasal cavity, pharynx, larynx, trachea, bronchi and lungs. It carries air between the lungs and the body's exterior.

The organs responsible for respiration are the nasal cavity, pharynx, larynx, trachea, bronchi and lungs. The nasal cavity follows the external nose. The nose is a visible prominent structure. The nasal passage opens outside through external nostrils. It opens inside through the internal nostrils at pharynx.

The trachea (or windpipe) is a membranous tube supported by 'C' shaped cartilage rings. The inner wall is lined by mucous membrane. It consists of ciliated columnar epithelium.

Respiratory area



The pathway of air from the nose to the larnyx

The total surface of the alveoli will be around 80-100 square metres and is equal to the size of the tennis court.

Lungs

The pair of lungs is the main organ of respiration. It is conical in shape and placed inside the thoracic chamber. The base of the lungs rests on the diaphragm. The right lung has three lobes and the left lung has two lobes.

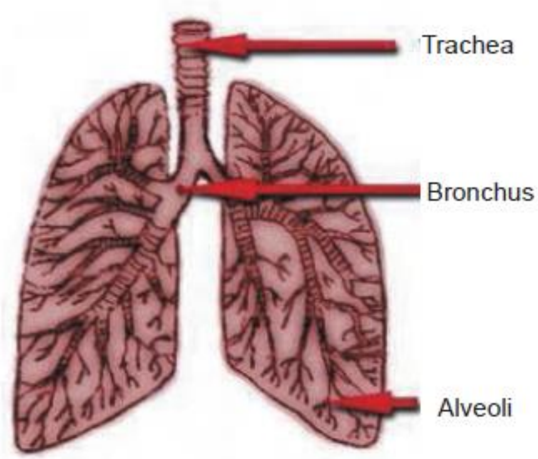
Each lung is surrounded by a double wall membrane called pleura. The region inside the pleural membrane is named as the pleural cavity. This cavity is filled with pleural fluid.

The primary bronchi on entering into each lung is divided further into the secondary bronchi. The secondary bronchi in turn gives rise to the tertiary bronchi. They divide still further and finally gives rise to bronchioles. The bronchioles divide several times to become smaller terminal bronchioles. The terminal bronchioles end in small air-filled chambers called alveoli. This is the place, where exchange of gases takes place. The exchange of two gases (O2 and CO2) occurs by simple diffusion. Human lungs have about 300 million alveoli.

- *People suffer due to smoke. Smoke contains a large amount of CO, a toxic gas.*

- *The respiratory pigment haemoglobin has affinity towards O_2, more affinity towards CO_2 and most affinity towards CO. That is why, people when engulfed in smoke in a place on fire die due to suffocation.*

- Dogs regulate body temperature by panting.



Structure of Lungs

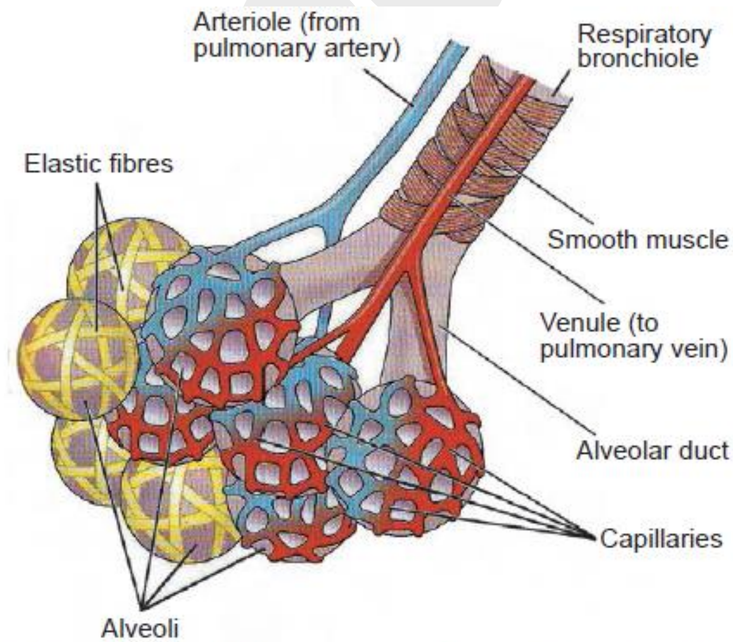
Functions of Lungs

1. The lungs take in oxygen-rich air and expel carbon dioxide from the body.
2. It also excretes water vapour.

MARCELLO MALPIGHI (1628-1694)

Marcello Malpighi, born in Italy in March 1628, studied Aristotelian Philosophy and graduated as a medical doctor. Malpighi developed an intense interest in scientific researchwith a fond love for teaching. He is considered as the founder of Comparative Psychology. In 1669, Malpighi published the result of his work on the silkworm. He discovered that these insects had no lungs, but breathed through a row of holes located on the lateral side of their long bodies. Distribution of air within the insect occurs through a system of tubules that Malpighi termed as 'trachea'. While observing the dissected lung tissue, Malpighi discovered tiny, thin-walled microtubules, which he named as capillaries. He went on to hypothesize that the capillaries are the connection between arteries and veins that allow blood to flow back to the heart, and these are the vital organs which do all the functions of the circulatory system. A number of anatomical structures still bear his name - Malpighian corpuscles in the circulatory and lymphatic systems, the Malpighian layer of epidermis (rete malphigi) and the malpighian tube in insects. Excretion of nitrogenous waste such as uric acid and water removal from the faeces is carried out by Malpighian tubules.

The cartilagenous ridge found at the base of the trachea is called the carina. Foreign objects reaching carina stimulate a powerful cough.

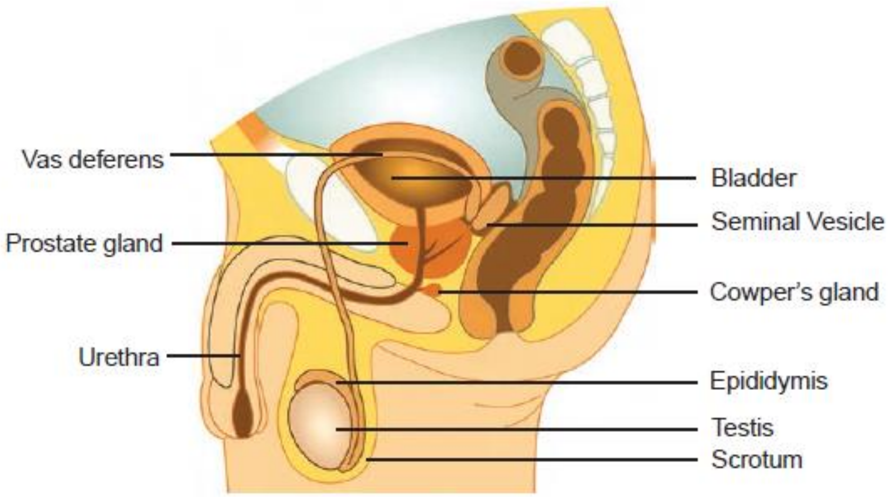


Enlarged view of the alveolus and its capillary network

2.8 REPRODUCTIVE SYSTEM

Male reproductive system

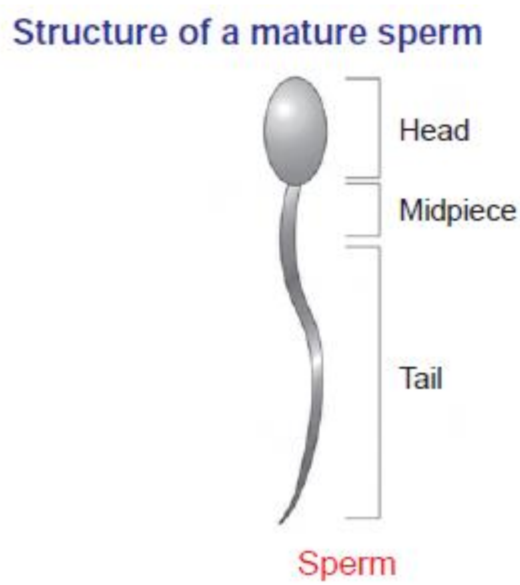
The male reproductive system includes the primary sex organs and accessory organs. The primary sex organs are the testes and the accessory organs are seminal vesicles, prostrate glands, urethra and penis.



Human male reproductive system

A pair of testes is located in the scrotum outside the abdominal cavity because sperm formation requires a lower temperature than the normal body temperature. Each testes contains a coiled mass of tubules known as seminiferous tubules which produce sperms. The process of formation of sperms is known as spermatogenesis. The interstitial cells of the testes also secrete the male sex hormones (androgens) which control spermatogenesis and play a role in the appearance of male traits such as growth of beard, moustache, body hair and hoarse voice.

The sertoli cells of the testis provide nourishment to the developing sperms. The sperms are delivered through the vas deferens which unites with the urethra which form a common passage for both sperms and urine. Along the path of vas deferens lies the seminal vesicles and the prostrate glands, which add their secretions so that the sperms are released in a fluid called semen. This fluid provides nutrition and helps in the transport of sperms.



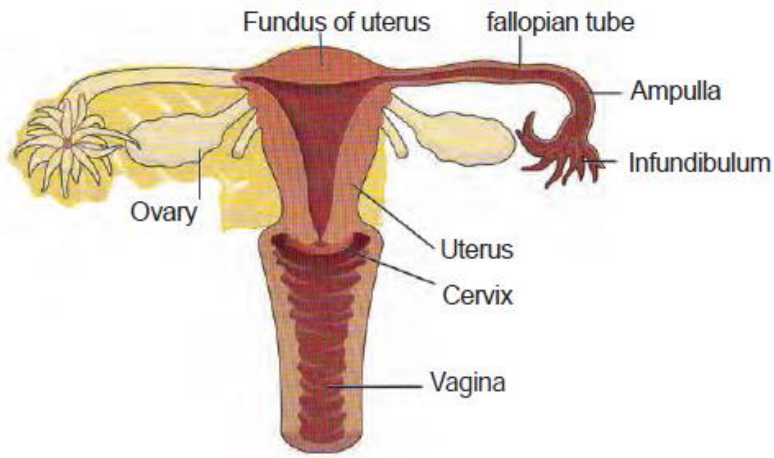
The sperm consists of four parts namely head, neck, midpiece and tail. The head contains a condensed nucleus containing haploid set (n) of chromosomes and a terminal acrosome (Golgi apparatus) containing hyaluronidase and proteolytic enzymes. The neck contains a proximal and a distal centriole. The distal centriole is continuous with axial filament.

The midpiece contains the spirally coiled mitochondria. The tail represents the remnants of cytoplasm and propels the sperm in the liquid medium. Female reproductive system The female reproductive system consists of ovaries and accessory organs such as fallopian tubes, uterus, cervix and vagina. The ovary produces an egg in every 28 days (menstrual cycle) apart from the female sex hormones, oestrogen and progesterone.

Each ovary consists of follicle cells, which produce the ovum by a process known as oogenesis. The uterus is a hollow, thick-walled muscular organ formed of three layers and the fertilized ovum is embedded and nourished in the uterus. Vagina is a muscular tube which connects the cervix and the external genitalia. It receives the sperms and serves as a birth canal. The oestrogen is responsible for oogenesis and for the appearance of female secondary sexual characters such as development of breasts, growth of hair and feminine voice.

The structure of egg of human ovum

The egg of human is alecithal (without yolk) and contains cortical granules and yolk platelets. The egg is surrounded by a number of egg membranes.



Human female reproductive system

1. Vitelline membrane – The ovum is surrounded immediately by a thin transparent membrane.

2. Zona pellucida – It is a thick transparent membrane above the vitelline membrane.

3. Corona radiata – The outermost thick membrane formed by the follicle cells. The fluid-filled cyst inside which an ovum develops is called a Graffian follicle.

Menstrual cycle

The rhythmic series of changes that occur in the female sex organs for about 28 days throughout the reproductive life of women from puberty to menopause (except during pregnancy) is known as the menstrual cycle.

After ovulation, the mature ovum is brought to the fallopian tube and may get fertilized. When the ovum is not fertilized, the ovum along with the uterine wall is ruptured and discharged with blood and the uterine tissue by a process called menstruation.

It involves three phases namely

1. The follicular phase(5th day –14th day)
2. The luteal phase or premenstrual phase (15th day – 28th day)
3. The menstrual phase (1st day – 5th day)

Anton van Leeuwenhock (1632 - 1723) was the first to observe and draw sperm cells.

Menstrual cycle

1. Follicular phase: This phase is initiated by the secretion of Follicle Stimulating Hormone (FSH) of pituitary. During this phase primary ovarian follicles begin to grow and the mature graffian follicles burst and release the ovum into the fallopian tube (ovulation).

2. Luteal phase: This stage is influenced by Lutenising Hormone (LH) of the pituitary gland. After the release of the ovum, the ruptured part of graffian follicle is transformed into a transitory endocrine gland called corpus luteum. It secretes the pregnancy hormone called progesterone. This hormone causes the thickness of endometrium and prepares the uterus to receive the fertilized ovum. If the ovum is not fertilized, the ovum and uterine wall gets ruptured and discharged during menstrual phase.

Sperm Bank
Sperms can be collected in the form of semen and can be stored in the sperm bank and kept viable for several years in frozen state in liquid nitrogen at a very low temperature. These sperms are useful in invitro fertilization and artificial insemination techniques.

3. Menstrual phase: The decline in progesterone and oestrogen initiates the shedding of unfertilized egg and endometrium with severe bleeding in a process called mensus or menstruation. At the termination of menstruation, the corpus luteum is converted into a scar tissue called corpus albicans.

Mechanism of fertilization

At the time of ovulation, the ovum is fully matured and it enters the infundibulum of the uterine tube and passes into the ampulla. Fertilization of the ovum takes place in the ampulla of the uterine tube. Only one spermatozoan pierces the egg membrane Zona pellucida and enters the ovum. Polygamy (entry of more sperms) is prevented by the fertilization membrane around the ovum.

2.8.1 DEVELOPMENT OF EMBRYO

The fertilized ovum is called the zygote. As soon as it is formed, it becomes activated and mitotic divisions set in. This is the first phase of the embryo's development and is called the cleavage. As a result, a ball of cells called the blastula is formed. The outer surface forms the trophoblast and the embryo gets attached to the wall of the uterus. This process is known as implantation.

The implanted embryo develops the extra embryonic membranes such as amnion, allantois, chorion and yolk sac. Amnion provides a fluid medium to the developing embryo. It prevents dessication of the embryo and functions as a shock absorber. The chorion and allantois fuse to form the placenta. It helps in the exchange of gases between the mother and the foetus and also the elimination of nitrogenous waste from the foetus. The embryo and the placenta are connected by the umbilical cord, which is derived from the allantois.

Stages in the development of the human foetus:

Gestation period : From the fertilization of the ovum to the birth of the baby, it takes about nine months. The period during which the foetus remains inside the uterus is called the gestation period.

The development of foetus can be studied as phases of three month period:
The first, second and third trimesters.

First trimester

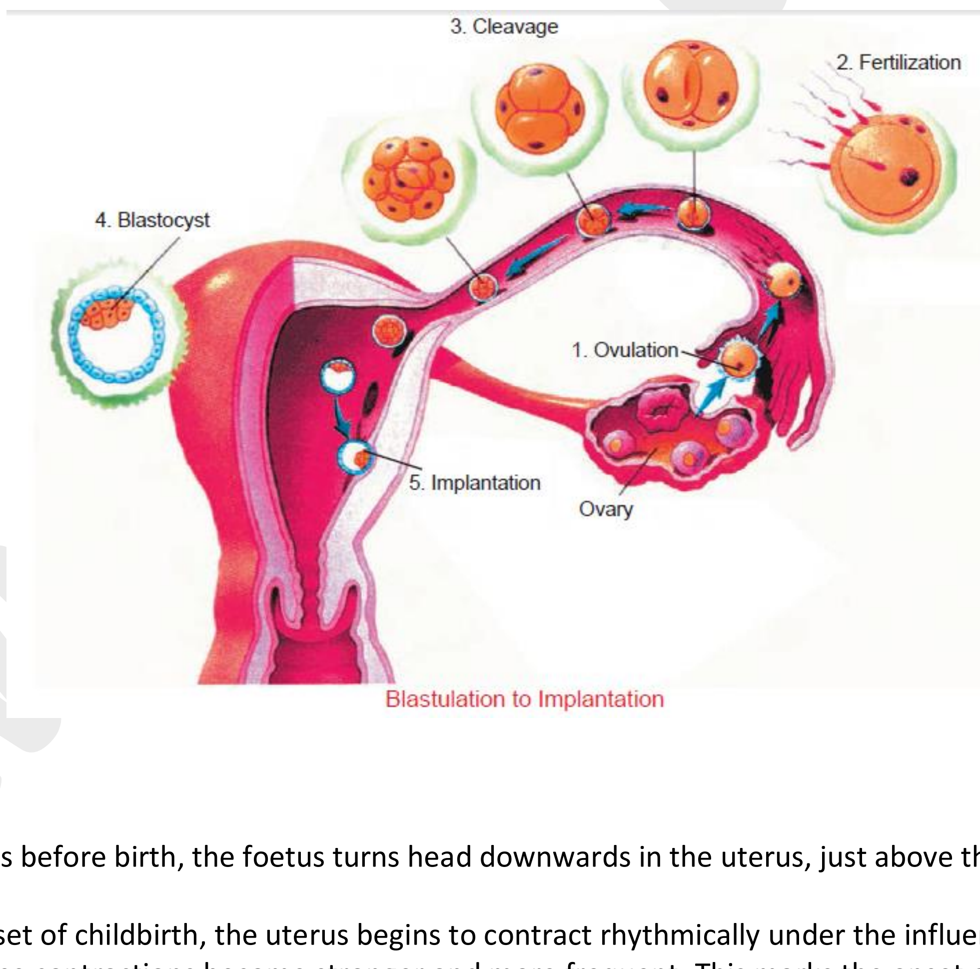
During this period, the proliferation of cells takes place and a single cell is transformed into a foetus gradually. Organogenesis takes place resulting in the formation of organs.

Second trimester

The foetus grows rapidly. The respiratory and circulatory systems become welldeveloped and functional. The bones and muscles are well formed.

Third trimester

The length and weight of the foetus increases very rapidly and the development is completed.



Blastulation to Implantation

Childbirth

A few days before birth, the foetus turns head downwards in the uterus, just above the cervix.

At the onset of childbirth, the uterus begins to contract rhythmically under the influence of oxytocin hormone. These contractions become stronger and more frequent. This marks the onset of labour pain. With continued powerful contractions, the amnion ruptures and the amniotic fluid flows out through the vagina. Finally, the muscular contractions of the uterus and the abdomen expel the child through the dilated cervix and vagina.

The umbilical cord that still connects the child to the placenta is tied and cut. A few minutes later, the placenta breaks away from the uterus and is expelled as 'after birth'.

Lactation

The first milk produced by the mother's mammary glands just after childbirth is known as colostrum. It is rich in proteins and nutrients. It also contains antibodies that provide immunity for the newborn infant. The secretion of milk is stimulated by the pituitary hormone prolactin.

Advantages of mother's milk

- It is clean, uncontaminated, easily available and sterile. ff It is available at a correct temperature for the baby's needs.
- It contains antibodies which shield the baby from external viral and bacterial infections.
- In rural areas, breast milk is used as eye drops for viral conjunctivitis and minor eye infections as a first aid.
- The calorific value of breast milk is 70 per 100 ml of milk and this can meet the requirements of the infant fully.
- Lactoferin, a protein in breast milk, provides considerable protection against intestinal and respiratory infections.

52] Bio - Geo Chemical Cycle

The cyclic flow of elements or compounds between the non-living environment (soil, rock, air, water) and the living organisms is known as bio-geo chemical cycle. These chemicals are used by living organisms and released back into the environment when they die and decompose. Thus there is an inter-dependence between the living and the non-living to help them complete a life cycle. Green plants are the producers and the animals that eat them are the consumers. The bacteria and fungi are the decomposers that break down the dead remains and release the chemicals for the plants to use again.

The abiotic or non-living components of the environment are air, water, soil, light and temperature. The biotic or living components of the environment include all living organisms including human beings. The ecosystem (Environmental system) includes these two essential components. The organisms and the physical environment of the habitat form an ecological complex termed the ecosystem.

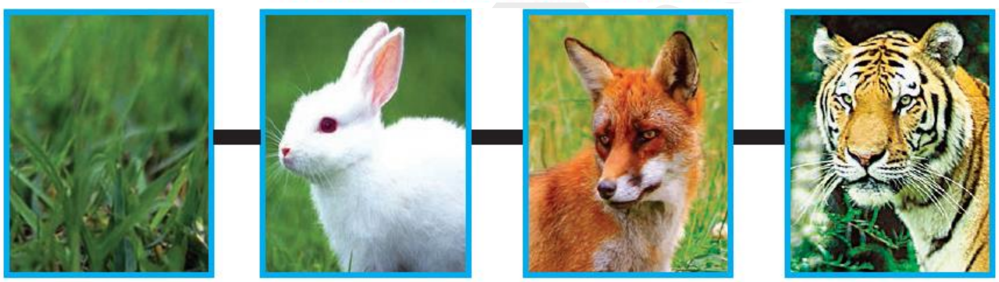
The branch of Biology which deals with the interrelationships between organisms and their environment is called Ecology. The energy trapped by green plants or autotrophs is relayed through a series of heterotrophic organisms or consumers. This forms the food chain. Living organisms take in oxygen during respiration and give out carbon dioxide. The plants absorb this CO_2 during photosynthesis and liberate oxygen into the atmosphere. Thus, plants and animals are interdependent.

WATER CYCLE

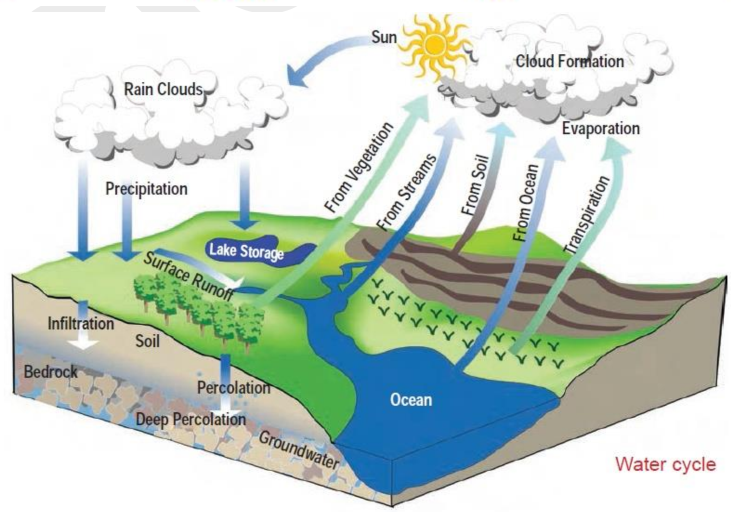
Water is an important component of the environment and is essential for living beings. Oceans are the biggest storehouses of water from which water evaporates to form clouds. Water also evaporates from other water bodies like rivers, lakes and ponds to form clouds.

On condensation, the water vapour in the clouds comes down as rain. The rainwater flows through rivers and eventually reaches the oceans.

Interaction between insects and plants



Grass Rabbit Fox Tiger



Water cycle

The circulation of water also occurs through plants and animals. Plants absorb water from the soil or a water reservoir and add it to the air (atmosphere) as vapour by transpiration. This plays a role in determining the micro climate around them.

Animals take water directly from the reservoir or through food. They release the water back into the environment by evaporation and excretion. Water is also added to the environment by death and decay of organisms.

A large amount of water is recycled directly without the involvement of biotic components. The heat of the sun and the movement of the wind help to evaporate water from the exposed surfaces of oceans and lakes. This water vapour enters the atmosphere and it becomes clouds which later transforms into water in the form of rain or snow. The rivers and lakes act as reservoirs of water which finally collects in the oceans.

More to know

About two-thirds of our body is made up of water.

The Earth's water supply is composed of 97% oceans, 2% ice caps, 1% fresh groundwater.

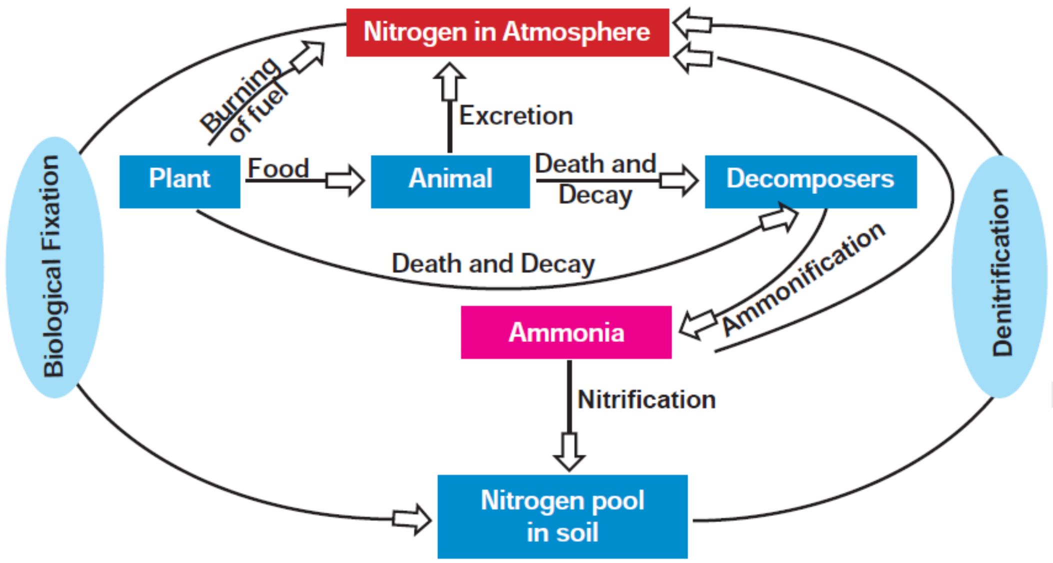
In 20 minutes, one thunderstorm can send down over 125,000,000 gallons of water. (One gallon is equivalent to 4.5 litres)

NITROGEN CYCLE

Living organisms require nitrogen to create proteins and nucleic acids in their body. The atmosphere consists of almost 78% of nitrogen, but plants and animals can use it only if it is in the form of ammonia, amino acid or nitrates. The process by which these forms get interconverted by physical and biological processes is called the Nitrogen Cycle.

The Nitrogen Cycle involves:

i. Nitrogen fixation
ii. Nitrogen assimilation
iii. Ammonification
iv. Nitrification and
v. Denitrification.



Nitrogen Cycle in Nature

Organisms involved in Nitrogen Cycle

Activity	Name of organism
Nitrogen Fixation	Rhizobium, Azotobacter and Nostoc
Ammonification	Ammonifying bacteria and fungi
Nitrification	Nitrosomonas and Nitrobacter
Denitrification	Pseudomonas

The process of converting nitrogen gas into compounds of ammonia is called nitrogen fixation. Plants cannot use nitrogen directly from the atmosphere.

They depend on nitrogen fixing bacteria such as azotobacter, rhizobium and blue green algae like Nostoc that convert gaseous nitrogen into ammonia and nitrates. Nitrogen in the atmosphere is also oxidized by lightning to oxides that dissolve in rainwater and are washed into the soil. Nitrogen fixing bacteria are found in the soil. Some of them are also found in the roots of leguminous plants like peas and beans.

Nitrogen assimilation

The nitrates absorbed by plants are utilized for making organic matter such as proteins and nucleic acids. Plant proteins and other nitrogenous compounds consumed by animals are converted into animal proteins.

Ammonification

Animal proteins are excreted in the form of urea, uric acid or ammonia. When plants and animals die, their proteins are broken down to release ammonia by the action of bacteria and fungi. This process of ammonia formation is called ammonification.

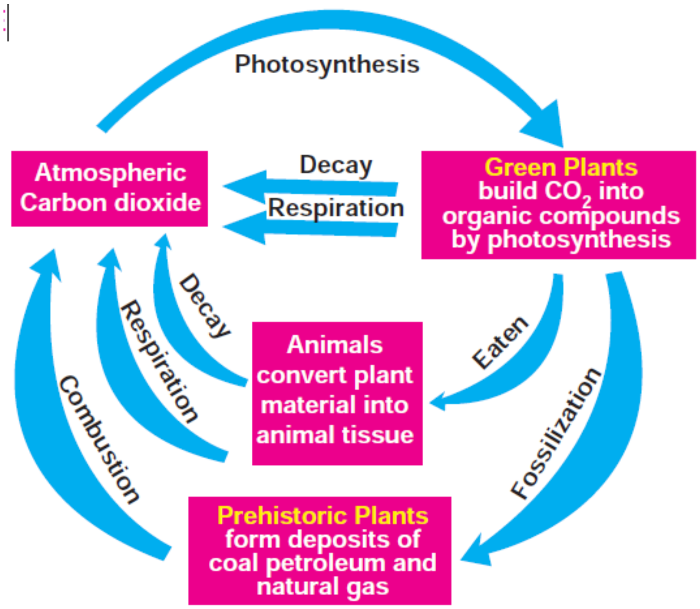
Nitrification

During this process, ammonia is converted into nitrites and nitrates by soil bacteria such as Nitrobacter and Nitrosomonas, which are then absorbed by plants through their roots.

Denitrification

Free living soil bacteria such as Pseudomonas reduce nitrate ions of soil into gaseous nitrogen which returns to the atmosphere.

CARBON CYCLE



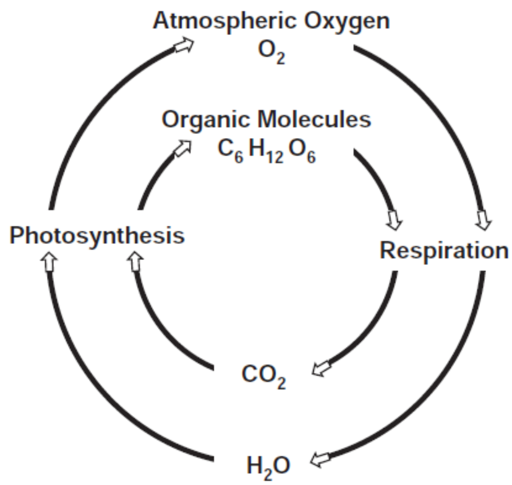
Carbon Cycle

All living organisms are made up of compounds that contain carbon. The three main sources of carbon are: i) CO_2 in the air and CO_2 dissolved in oceans ii) Carbonate rock in the earth's crust iii) Fossil fuels like coal and petroleum. The element carbon moves from the atmospheric reservoir to the producers, to the consumers and then to the decomposers.

The atmospheric carbon dioxide enters into the living world i.e. green plants, through the process of photosynthesis to form carbohydrates (food). Plants are eaten by the herbivores and the carbon is passed to the small and the large carnivores.

Carbon is released back into the atmosphere through respiratory activities at each trophic level. Carbon dioxide is also returned to the atmosphere through decomposition of dead organic materials, burning of fossil fuels and volcanic activities.

OXYGEN CYCLE



Oxygen Cycle

For respiration, oxygen exists as part of water. Oxygen forms about 20% of air in the atmosphere. It enters the living world through respiration. It oxidizes food materials and produces energy. The carbon dioxide that is released in the process is utilized by the plants to produce food materials through photosynthesis and oxygen is libarated back into the atmosphere.

More to know

Without the carbon cycle, carbon would not be recycled, resulting in the inability for living things to survive.

53] CHEMICAL EQUATION

Plants produce their food (carbohydrate) by a chemical reaction called photosynthesis. The process of photosynthesis requires: (i) carbon dioxide (ii) water (iii) sunlight (iv) chlorophyll. This can be represented by the equation:

$$\text{Carbon dioxide + Water} \xrightarrow[\textit{Chlorophyll}]{\textit{Sunlight}} \text{Carbohydrate + Oxygen} \uparrow$$

Thus, chemical equations summarize information about chemical reactions. To write a chemical equation, you must know the substances that are present before and after the reaction, such as reactants and products.

TYPES OF IONS

In general, atoms and molecules take part in chemical reactions.

We know that atoms are made up of particles called protons, neutrons and electrons. Protons are positively charged, while electrons are negatively charged. An atom has no net charge. It is said to be electrically neutral, since it has an equal number of protons and electrons.

In chemical reactions, the number of protons in an atom remains unchanged, whereas the number of electrons may increase or decrease. This leads to a difference in the number of protons and electrons giving a net electrical charge to the atom. When an atom acquires a net charge, it is called an iron.

Ions are atoms or group of atoms that carry a net positive or negative charge.

CATIONS

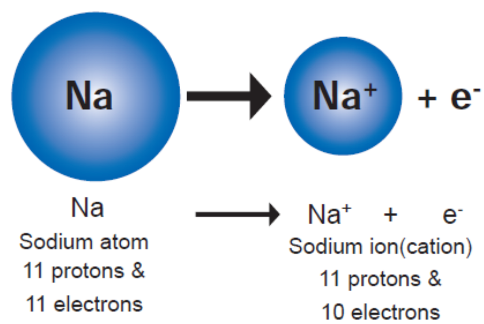
If an atom, which is electrically neutral, loses one or more electrons, it becomes positively charged and is called a cation.

$$\text{Atom} \longrightarrow \text{cation} + \text{electron(s)}$$

Typically, when metals are involved in a chemical reaction, they lose electrons to form cations.

Formation of sodium ion from sodium atom

For example, sodium is a metal. The atomic number of sodium is 11. A sodium atom loses one electron and forms a sodium ion.



cation is +ve

ANIONS

If an atom, which is electrically neutral, gains one or more electrons, it becomes negatively charged and is called an anion.

$$\text{Atom} + \text{electron(s)} \longrightarrow \text{Anion}$$

Typically, when non-metals are involved in a chemical reaction, they gain electrons to form anions.

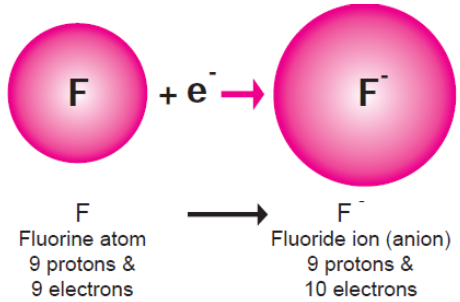
More to know

Did you notice that the cation is smaller than the parent atom? This is because the nucleus pulls the electrons towards it, as the number of protons is more than the number of electrons.

Formation of fluoride ion from fluorine atom.

For example, fluorine is a non-metal. The atomic number of fluorine is 9. A fluorine atom gains one electron and forms a fluoride ion.

Fluorine gains one electron



Monoatomic ions A monoatomic ion is formed from a single atom.

For example, Sodium ion Na^+ is a monoatomic cation and Fluoride ion F^- is a monoatomic anion.

More to know

- *Did you notice that the anion is larger than the parent atom? This is because the number of protons is fewer than that of electrons and thus the nucleus has lesser influence on the valence electrons. The valence electrons move away from the nucleus, which increases the size of an anion.*
- *The names of most monoatomic negative ions end with the suffix"-ide".*

Polyatomic ions

An ion can also be formed from one or more atoms of different elements. This is called a polyatomic ion. A polyatomic ion exists and behaves as a single unit. It may carry either a positive or a negative charge.

Example: NH_4^+ is Ammonium ion (polyatomic cation)

OH^- is Hydroxide ion (polyatomic anion)

More to know

A molecule formed by the combination or association of two molecules is known as a dimer.

Hg_2^{2+} Mercurous ion exists as a dimer only.

IONS AND VALENCY

The valency of an element is the net charge on the ion of that element. For a polyatomic ion, the net charge of the group is its valency.

	Monoatomic ion		**Polytomic ion**	
	Cation	**anion**	**Cation**	**anion**
Monovalent	Na^+	F^-	NH_4^+	OH^-
Divalent	Ca^{2+}	S^{2-}		So_4^{2-}
Trivalent	Fe^{3+}	N^{3-}		PO_4^{3-}

Monovalent polyatomic ions

Name	**Formula**
Bisulphate ion	HSO_4^-

Bisulphite ion	HSO_3^-
Chlorateion	ClO_3^-
Chlorite ion	ClO_2^-
Cyanide ion	CN^-
Hydroxide ion	OH^-
Hypochlorite ion	ClO^-
Nitrate ion	NO_3^-
Nitrite ion	NO_2^-
Perchlorate ion	ClO_4^-
Permanganate ion	MnO_4^-

More to know

Most of the names of polyatomic negative ions end with suffixes "-ite", "-ate".

Bivalent polyatomic ions

Name	**Formula**
Carbonate ion	CO_3^{2-}
Chromate ion	CrO_4^{2-}
Dichromate ion	$Cr_2O_7^{2-}$
Manganate ion	MnO_4^{2-}
Peroxide ion	O_2^{2-}
Sulphate ion	SO_4^{2-}
Sulphite ion	SO_3^{2-}
Thiosulphate ion	$S_2O_3^{2-}$

Trivalent polyatomic ions

Name	***Formula***
Borate ion	BO_3^{3-}
Phosphate ion	PO_4^{3-}

Multivalent cations or polyvalent cations

Formula	**Name**	**Formula**	**Name**
Au^+	Gold (I) or Aurous	Au^{3+}	Gold (III) or Auric
Ce^{3+}	Cerium (III) or Cerous	Ce^{4+}	Cerium (IV) or Ceric
Co^{2+}	Cobalt (II) or Cobaltous	Co^{3+}	Cobalt (III) or Cobaltic
Cr^{2+}	Chromiunm (II) or Chromous	Cr^{3+}	Chromiun (III) or Chromic
Cu^+	Copper (I) or Cuprous	Cu^{2+}	Copper (II) or Cupric
Fe^{2+}	Iron (II) of Ferrous	Fe^{3+}	Iron (III) or Ferric
Mn^{2+}	Manganese (II) or Manganous	Mn^{3+}	Manganese (III) or Manfanic
Pb^{2+}	Lead (II) or Plumbous	Pb^{4+}	Lead (IV) or Plumbic

Sn^{2+}	Tin (II) or Stannous	Sn^{4+}	Tin (IV) or Stannic

CHEMICAL FORMULA

A Chemical formula is a symbolic way to represent a compound. To write the chemical formula of a compound, symbols and valencies of constituent elements must be known. Chemical symbols and valencies

Valency = 1	**Valency = 2**	**Valency = 3**	**Valency = 4**
Bromine (Br)	Barium (Ba)	Boron (B)	Carbon (C)
Chlorine (Cl)	Calcium(Ca)	Aluminium(l)	Silicon(Si)
Fluorine (F)	Magnesium (Mg)		
Hydrogen (H)	Oxygen (O)		
Iodine (I)	Sulphur (S)		
Lithium (Li)			
Sodium (Na)			
Potassium(K)			

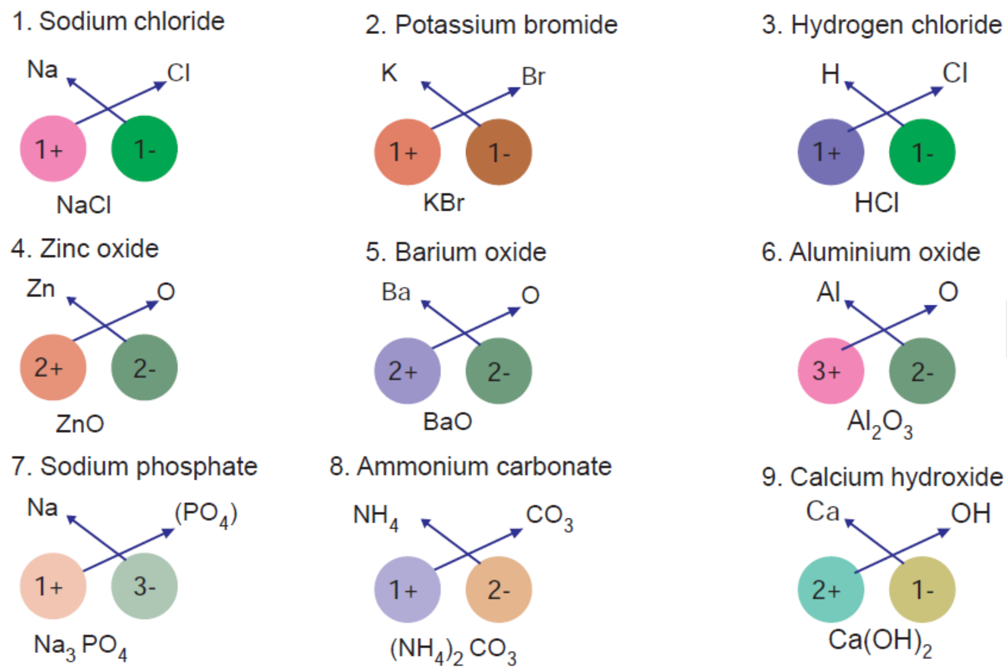
WRITING A CHEMICAL FORMULA BY VALENCY CRISS-CROSS METHOD

The chemical formula of a compound is electrically neutral. The charge on the cations and the charge on the anions must be equal. (Remember, the valency can be related to the charge).

The following methods are followed to write a chemical formula.

- The symbols or formulae of the components are written side by side.
- Positive ions are written on the left and negative ions on the right.
- The valencies of ions are written below the respective symbols.
- The criss-cross method is applied to exchange the numerical value of valency of each ion. It is written as subscript of the other ion.
- For a polyatomic ion, the ion is enclosed within brackets and the subscript is placed outside the lower right corner.
- The common factor is removed.
- If the subscript of the ion is one, it is omitted.

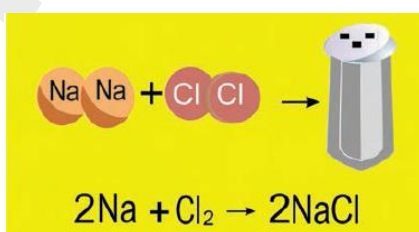
Illustrations



The symbolic expression of a chemical reaction, using symbols of reactants and products, is called a chemical equation.

Reactant A+ Reactant B $\longrightarrow$ Product(s)

- Reactants are the starting substances.
- Products are the substances that are formed in a reaction.
- The arrow sign means “react to form”.
- The plus sign means “and”.



Remember the following points while writing a chemical equation:

(i) Nature of reactants and products

The physical state of a substance can be indicated using the following symbols as a subscript:

Physical State	Symbol	Example
Solid state	(s)	$NaCl_{(s)}$
Liquid state	(l)	$H_2O_{(l)}$
Gaseous state	(g)	$O_{2(g)}$
Solution in water	(aq)	$NH_{3(aq)}$

The following arrows are used to show the nature of the substances:

(↑) gas is released. Example: $O_{2(g)}$ ↑

(↓) precipitate is formed. Example: BaSO4↓

(ii) Reaction conditions:

Favourable conditions like temperature, pressure, presence of catalyst and light can be indicated above or below the arrow.

Example:

$$4NH_3 + 5O_2 \xrightarrow[Pt]{750^\circ\text{-}900^\circ C} 4NO + 6H_2O$$

(iii) Heat changes:

Some reactions involve heat changes.

Example:

$$N_2 + 3H_2 \rightleftarrows 2NH_3 + \text{heat}$$

Heat is released. This is an exothermic reaction.

More to know

Common Greek Prefixes

Prefix	Number
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Nona-	9
Deca-	10

BALANCING THE CHEMICAL EQUATION

The “Law of conservation of mass” requires that the number of atoms present before the reaction (reactants) must be equal to the number of atoms present after the reaction (products). In other words, the equation must be “balanced”.

In order to balance an equation:

1. Identify the reactants and the products and write the skeleton equation. For example:

$$\text{Reactant A} + \text{Reactant B} \longrightarrow \text{Product C} + \text{Product D}$$

2. Count the number of atoms on either side. If they are not equal, balance them by adjusting the number of reactants or products.
3. If the coefficients have a common divisor, simplify.

Example 1: Balance the reaction between Sodium and Chlorine.

Skeleton equation:

$Na + Cl_2 \rightarrow Nacl$

Balance Cl atom:

$Na + Cl_2 \rightarrow 2Nacl$

Balance Na atom:

$2Na + Cl_2 \rightarrow 2Nacl$

Example 2: Balance the reaction of Sodium Carbonate with Hydrochloric Acid.

Skeleton equation:

$Na_2Co_3 + HCl \rightarrow NaCl + H_2O + CO_2$

Balance sodium atom:

$Na_2Co_3 + HCl \rightarrow 2NaCl + H_2O + CO_2$

Balance hydrogen, chlorine and oxygen atoms:

$Na_2Co_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

Example 3: Balance the reaction of Aluminium Hydroxide with Sulphuric Acid.

Skeleton equation:

$Al(OH)_3 + H_2\,SO_4 \rightarrow Al_2\,(SO_4)_3 + H_2\,O$

Balance aluminium atom.

$2Al(OH)_3 + H_2\,SO_4 \rightarrow Al_2\,(SO_4)_3 + H_2\,O$

Balance sulphate group:

$2Al(OH)_3 + 3H_2\,SO_4 \rightarrow Al_2\,(SO_4)_3 + H_2\,O$

Balance hydrogen and oxygen atoms:

$2Al(OH)_3 + 3H_2\,SO_4 \rightarrow Al_2\,(SO_4)_3 + 6H_2\,O$

Illustration : 1

Reaction between Sulphur dioxide and Oxygen to form Sulphur trioxide:

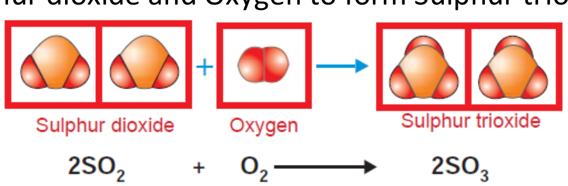


Illustration : 2

Reaction between Hydrogen and Chlorine to form Hydrogen chloride:

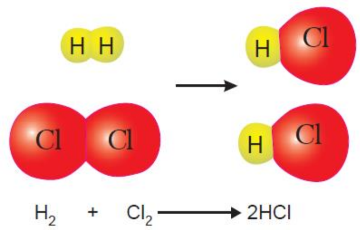
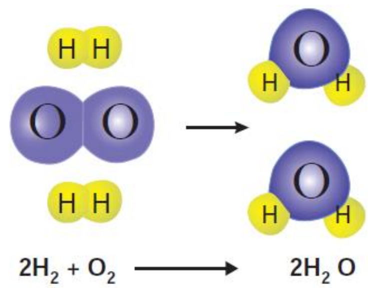


Illustration : 3

Reaction between Hydrogen and Oxygen to form water:



Let's know the occurrence of a natural chemical reaction.

Some chemical reactions take place naturally during lightning. Nitrogen in the atmosphere combine with oxygen to form nitrogendioxide.

$$N_2 + 2O_2 \longrightarrow 2NO_2$$

Oxygen present in the atmosphere is converted to ozone.

$$3O_2 \longrightarrow 2O_3$$

This acidic oxide like nitrogendioxide mixes with tiny droplets of water vapour to produce acid rain which is harmful to plants.

$$4NO_2 + O_2 + 2H_2O \longrightarrow 4HNO_3$$

54] Sound

SIGNIFICANCE OF SOUND

Sound has great importance in our daily life.

- Sound makes it possible for us to communicate with one another through speech. It enables us to share our thoughts and ideas with others.
- Musical sound gives us pleasure.
- Sounds from radio and television give us information and entertainment.
- Horn sounds (honking of vehicles) alert us and keep us safe on the road.

PRODUCTION AND PROPAGATION OF SOUND WAVES

From the above activities, we understand that by plucking, striking, rubbing and blowing we can produce sounds. Scratching and shaking different objects are other ways of producing sounds.

- All these activities set the objects vibrating. Vibrations are "repeated small to and fro motion of objects".
- These vibrations disturb the air particles close to the vibrating object, which in turn pass it on to other particles.
- Each to and fro movement causes a disturbance of air particles so that the continuously vibrating body causes a series of disturbances. The series of disturbances move through the atmosphere from the source in different directions. The series of disturbances travelling through the atmosphere are called sound waves.
- When these sound waves enter the ear of the listener, it sets the tympanic membrane in the ear vibrating, causing a sensation of sound in our ears.

Therefore, remember, sound waves are created by vibrating bodies and sound is a sensation 'heard' by the listener.

MORE ABOUT PROPAGATION OF SOUND WAVES

Sound waves can travel through liquids, solids as well as gases. The substance (solid, liquid or gas) through which the sound waves travel is called a medium. Sound waves need a material medium to propagate; they cannot travel through vacuum.

Robert Boyle, the scientist, proved that sound waves cannot pass through vacuum or empty space. He kept an electric bell inside a glass container, as shown in fig 5.1. He sucked the air slowly from the container using a vacuum pump. The volume of sound gradually decreased and no sound was heard, when the air was removed completely. By pumping the air back into the container the sound was once again heard.

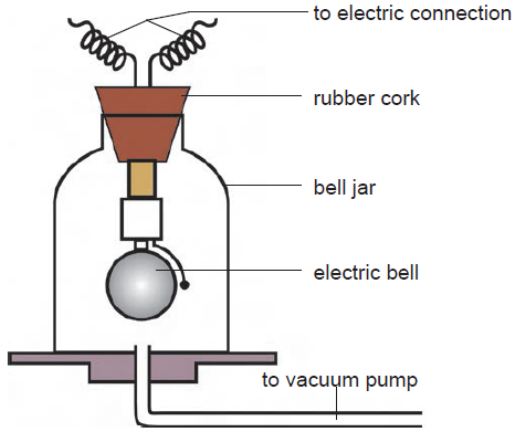


Fig. 5.1.Electric bell in jar

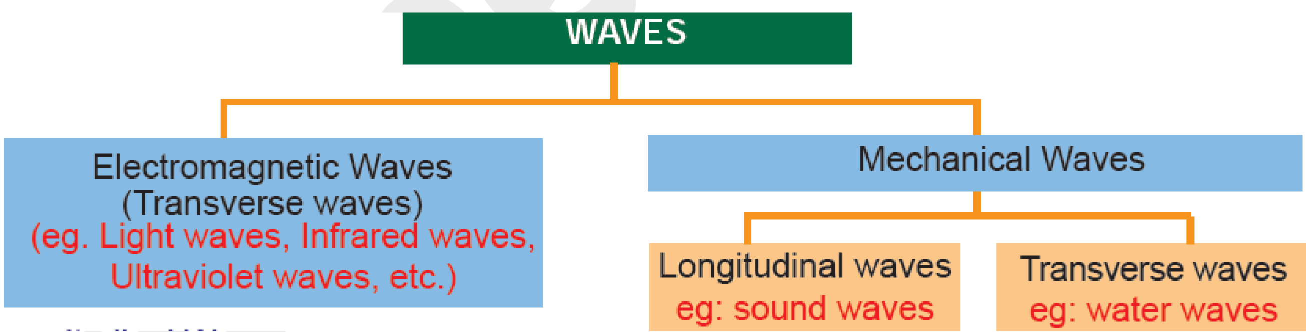
CHARACTERISTICS AND TYPES OF WAVES

In general, a wave is a series of disturbances that move through a medium. The particles of the medium do not move from the source to the destination, but the disturbance alone is carried from the source to the destination.

Waves that require a material medium to propagate, such as sound waves, are referred to as mechanical waves. Mechanical waves are of two kinds - longitudinal waves and transverse waves.

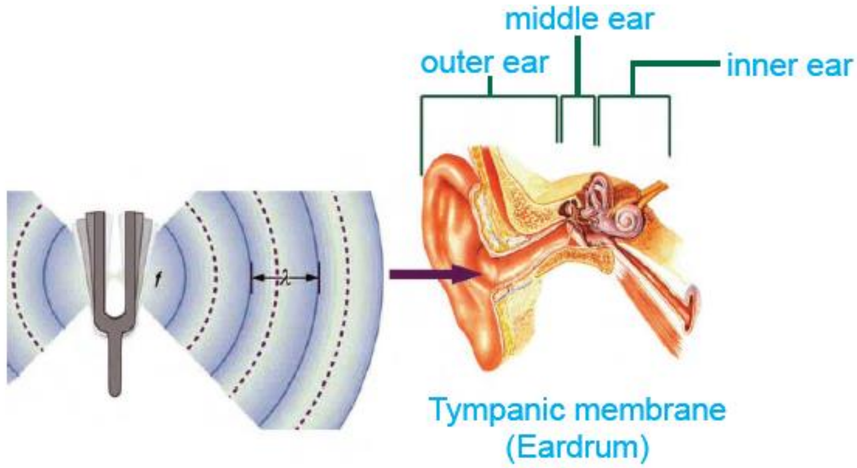
Some waves such as electromagnetic waves do not require a medium to propagate and can travel through vacuum. Radio waves are an example of electromagnetic waves. You will learn more about this in higher classes.

The types of waves are presented in this diagram for easy understanding.



Longitudinal Waves

"If the particles of a medium vibrate in a direction, parallel to or along the direction of the propagation of wave, it is called a longitudinal wave."



Sound waves travel in the form of longitudinal waves through gases.

Longitudinal waves propagate in a medium in the form of compressions and rarefactions as shown in fig. 5.2.

Compression is the area with maximum pressure, rarefaction is the area with minimum pressure.

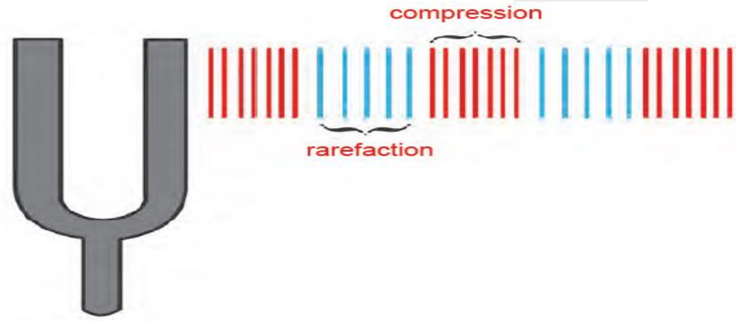
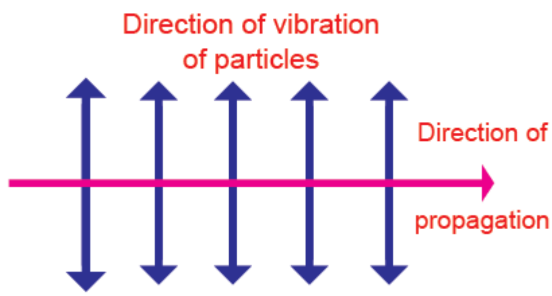


Fig. 5.2. Longitudinal waves

Transverse waves

"If the particles of the medium vibrate in a direction, perpendicular to the direction of propagation, the wave is called a transverse wave."



Examples of transverse waves are water waves and the vibration of stretched strings.

Transverse waves propagate in a medium in the form of crests and troughs as shown in fig 5.3.

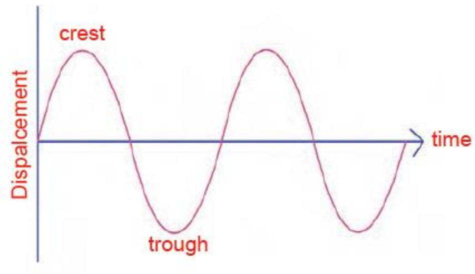


Fig 5.3. Transverse waves

Difference between Transverse and Longitudinal waves

Transverse waves	**Longitudinal waves**
Particles of the medium vibrate in a direction which is perpendicular to the direction of propagation.	Particles of the medium vibrate in a direction which is parallel to the direction of propagation.
Crests and troughs are formed.	Compressions and rarefactions are formed.
Can travel through solids and surfaces of liquids.	Can travel through solids, liquids and gases.
Eg. Water waves	Eg. Sound waves.

Definitions of some terms used in relation to waves:

Amplitude (a): The maximum displacement of a particle from the mean position is called amplitude. Its unit is metre.

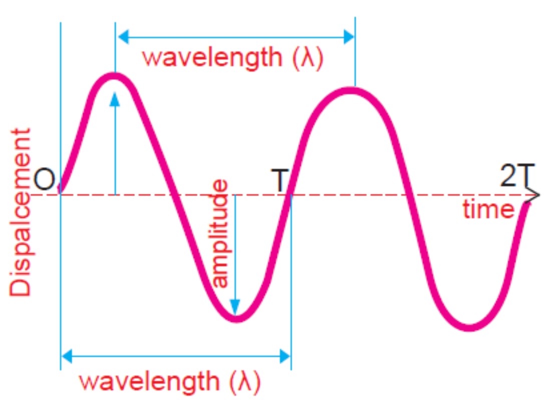
Time period (T) : Time taken by a particle of the medium to complete one vibration is called Time period. Its unit is second.

Frequency (n) : The number of vibrations completed by a particle in one second is called frequency . Its unit is hertz.

$$n = \frac{1}{T}$$

Wave Length (λ) : Distance moved by a wave during the time a particle completes one vibration. Its unit is metre.

Velocity = frequency x wavelength



Relation between Velocity of a wave, wavelength and Frequency

Distance travelled by a wave in one

Time period, T = λ (wavelength)

Velocity, $V = \frac{Distance}{Time} = \frac{\lambda}{T}$

But Frequency $n = \frac{1}{T}$

$\therefore v = n\lambda$

More to know

- *Sound travels almost five times faster through water and twenty times faster through iron than it travels in air. Speed of light (3×10^8m/s) is even faster than the speed of sound (340 m/s). This is why? Lightning flash is seen first and thunder sound (created by the lightning) is heard much later during thunderstorms.*
- *When we say we tune instruments, we mean that we adjust the instruments to have the same frequency or an exact multiple of it.*

REFLECTION OF SOUND WAVES

Echo

Sound waves can be reflected from large surfaces such as large walls of a building, sides of a hill or the walls of a cave. When reflected sound waves reach the ear, it can be heard distinctly after the original sound has stopped. This is called an Echo. The sensation of sound persists in our brain for about 1/10th of a second. If the reflected sound wave reaches the ear in less than 1/10th of a second, the brain cannot make out the difference between the original sound and the echo. If the reflected sound wave reaches the ear after 1/10th of a second, then a distinct echo can be heard.

Given that, sound waves travel at about 340 m/s at a temperature of 15°C, sound waves must travel about 34m, if it is to be heard as an echo. Therefore, to hear a distinct echo, the surface reflecting the sound should be at least 17 meters away.

Distance = velocity X time = 340 X 1/10

= 34 m.(17 m going and 17 m returning)

Reverberation

Echoes may be heard more than once due to successive or multiple reflections. The rolling of thunder is due to the successive reflections of the sound waves from a number of reflecting surfaces, such as clouds and lands. A sound wave created in a big hall will persist due to repeated reflections from the walls, until it is no longer audible.

The repeated reflections that result in the persistence of sound, often referred to as ‘rolling sound’ is called reverberation.

Audio recording theatre

In auditoriums, big halls, theatres and audio recording theatres, excessive reverberation is highly undesirable, as it will not be possible to enjoy the music or hear the speeches clearly. To reduce reverberation, the roofs and walls of auditoriums are generally covered with sound absorbing materials like compressed fibreboard, rough plaster or draperies. The seat materials are also selected on the basis of their sound absorbing properties, so that very little sound is reflected.

RANGE OF HEARING

Human beings can hear sound waves of frequencies ranging from 20 Hz to 20,000 Hz. This range of frequencies, sensed by the human ear is known as the audible range of sound. (one Hz= one cycle/second)

Sound waves of frequencies above 20,000 Hz are known as ultrasonic (the prefix 'ultra' I used to indicate 'higher'.) 'Ultrasonic' therefore, means frequencies higher than those heard by human beings. Sound waves of frequencies below 20Hz are called infrasonic (the prefix 'infra' is used to indicate 'lesser than'). Thus 'infrasonic' means frequencies lesser than those heard by human beings. Certain animals can produce and detect ultrasonic and infrasonic frequencies.

Heinrich Rudolf Hertz (1857 - 94)

Hertz, a German scientist, gave the first experimental proof of the existence of radio waves. He did research on the evaporation of liquids. He had a keen interest in meteorology also. The frequency of sound, which used to be measured in cycles/second was changed to hertz (Hz), in honour of Heinrich Hertz.

Audible range of sound for humans and certain animals


Human

20 - 20,000 Hertz


Bat

1000 - 1,50,000 Hertz


Elephant

16 - 12,000 Hertz


Dolphins

70 -1,50,000 Hertz


16- 40,000 Hertz


900 – 2,00,000 Hertz


Cat

100 - 32,000 Hertz


Dog

40 - 46,000 Hertz


Rabbit

1000 - 1,00,000 Hertz

APPLICATIONS OF ULTRASOUND

SONAR (SOund Navigation And Ranging)

The word "SONAR" is an acronym for "SOund, Navigation And Ranging". A sonar consists of transmitter, detector, and display. The transmitter produces and transmits pulses of ultrasonic waves. These waves travel through water and after striking some underwater object such as the seabed or a shoal of fish, get reflected and are received by the detector. If the speed of sound in water is approximately 1440 metres per second, the time lapse between the transmitted signal and the received echo can be measured and the distance to the object can be calculated.

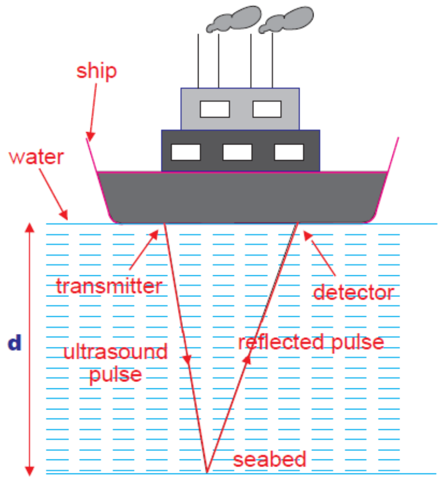


Fig 5.4. Ultrasound sent by the transmitter and received by the detector

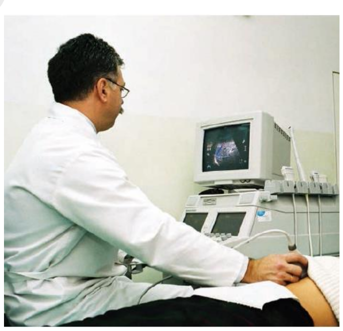
Example: Let us assume that the time interval between the transmitted pulse and the reflected pulse is 3 seconds and that the speed of sound in water is 1440 m/s then, the distance to the object would be:

$$\frac{(1440 \text{ m/s X } 3 \text{ seconds})}{2} = 2160 \text{ m}$$

This method of finding the distance is called Echo Ranging. It is used to determine the depth of the sea and to locate underwater objects, submarines, icebergs, sunken ships etc.

ULTRA SONOGRAPHY

'Ultrasonic waves' can be used to visualize inner organs of the human body. Pulses of ultrasonic waves are passed through parts of the body, which get reflected by organs. When several pulses are sent and received, it is possible to build a picture of the object reflecting the wave pulses. This is called ultrasonography and is used to visualize different organs, especially the human foetus inside the uterus before the baby is born. Doctors can monitor the condition of the baby by looking at the ultrasonographic image. The picture of a medical professional carrying out an ultrasonic scan and an image of the baby in the uterus are shown here.



DOPPLER EFFECT

When you stand on a railway platform and listen to a train engine blow its whistle you will notice that the sound is shriller and higher pitched, when the train approaches. (When the term 'higher pitched' is used, it implies that the frequency is higher). When the train moves away from your position, the same whistle will sound less shrill and lower pitched (When the term 'lower pitched' is used, it implies that the frequency is lower). Have you ever wondered why this happens?

Doppler was the first to explain this phenomenon and hence, it has been named after him as the Doppler Effect.

If an observer is situated at a fixed distance from a sound source, the frequency of sound heard by him/her is the same as that produced by the source. But if there is relative motion between the source of sound and the observer, the frequency of the sound appears to be changed to the observer. When the source approaches the observer, the frequency seems higher than that produced and when the source moves away from the observer, the frequency seems lower than the frequency produced.

Christian Johann Doppler (1803 – 53)

Christian Andreas Doppler was born on November 29, 1803, in Salzburg, Austria. After his death, he was referred to as Christian Johann Doppler for some reason.

In 1842, Doppler published the paper "Concerning the Coloured Light of Double Stars", which contained his first statement describing the Doppler Effect. He theorized that since the pitch of sound from a moving source varies for a stationary observer, the colour of light from a star should alter, according to the star's velocity relative to the Earth. Christian Doppler died on March 17.

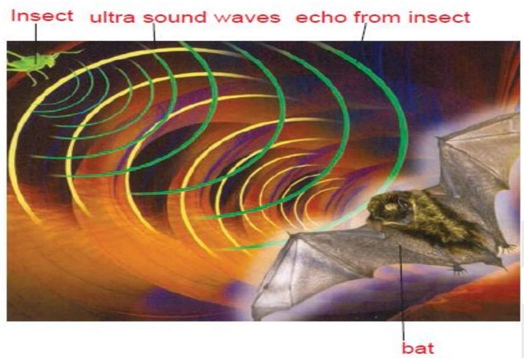
Uses of Doppler Effect in Sound

We studied that by measuring the time delay between a transmitted pulse and the reflected pulse, we can estimate the distance of the object reflecting the sound. By measuring the change in the frequency of the transmitted pulse and the reflected pulse, it is possible to estimate the velocity of the object reflecting the pulse. This is called Doppler Processing. Doppler Processing is used in SONAR to find the velocity of the object reflecting the transmitted pulse.

Bats send out and receive the ultrasonic waves reflected by the prey and obstacles. Bats therefore can not only detect the location, but can accurately predict the movement of the prey by the Doppler shift in frequency.

In airports, Doppler shift is used to distinguish the echoes received from the moving aircraft from the echoes received from stationary objects and to accurately find the height, speed and distance of approaching aircrafts.

Traffic control vehicles direct microwaves on speeding vehicles. From the Doppler shift in frequency, the speed of a vehicle is accurately calculated.



55] Structure And Physiological Functions Of Plants

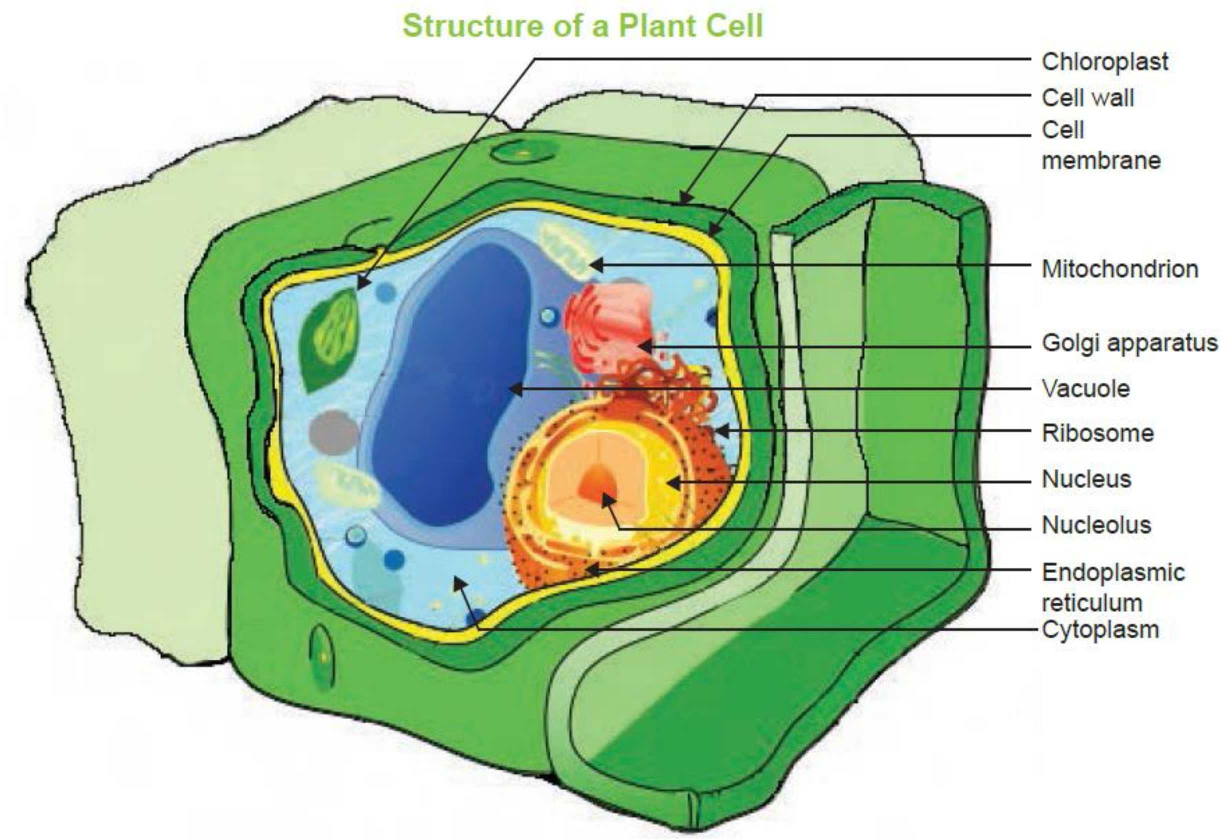
Physiology involves the study of the physical, chemical and biological functions of plants.

1.1. PLANT CELLS

Cells are the structural and functional units of all living organisms. The study of the structure and function of the cell is called Cytology or Cell biology.

A plant cell is typically rectangular or cube shaped. It has an outer covering called cell wall which protects and gives it shape. A cell membrane, also known as the plasma membrane, surrounds the cytoplasm and its organelles. The plasma membrane, cytoplasm and the nucleus together are referred to as the protoplast. The cytoplasm carries various cell organelles like endoplasmic reticulum, mitochondria, chloroplast, Golgi bodies and ribosomes.

Groups of cells having a common origin and performing similar functions are called tissues.



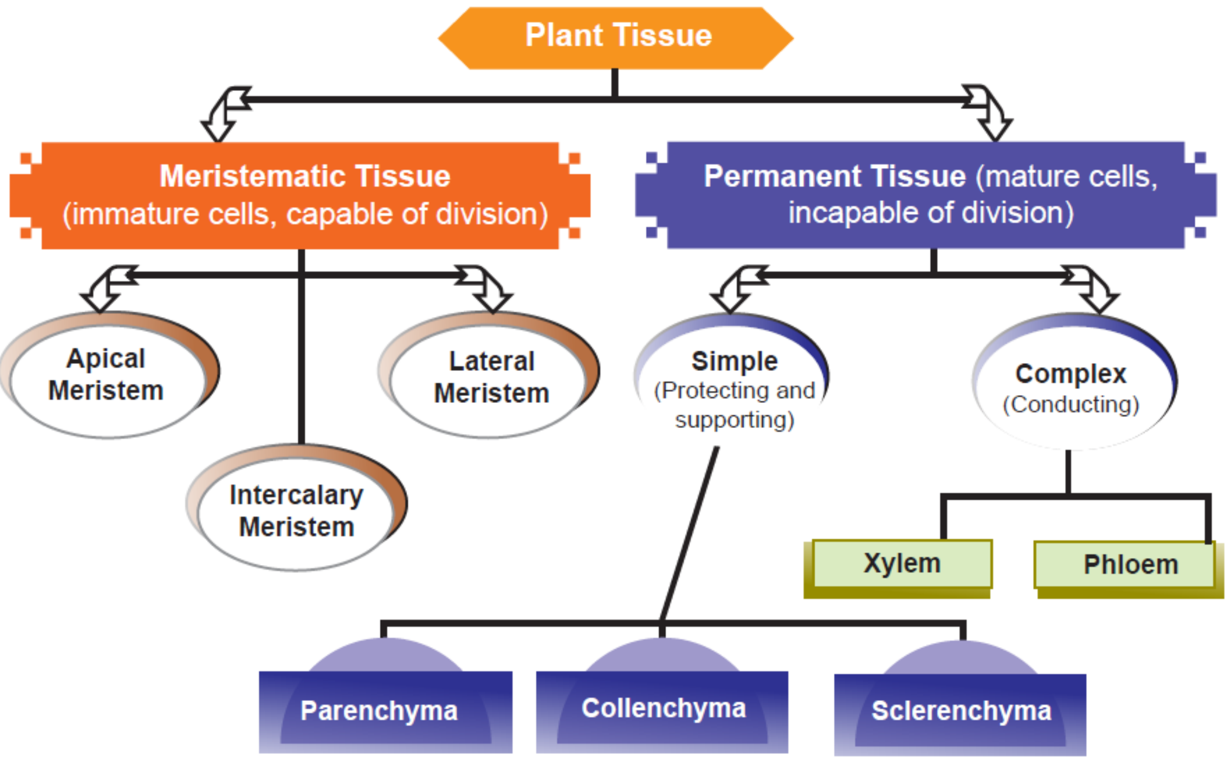
1.2. TISSUES

Types, Structure and Function of Plant Tissues

The progressive evolution in plants has resulted in the increasing complexity of structures. In higher plants, roots, stems, leaves and flowers carry out different functions. Due to this division of labour, the cells of the plants are differentiated to form different tissues.

The diagram given below shows the classification of different tissues:

CLASSIFICATION OF TISSUES



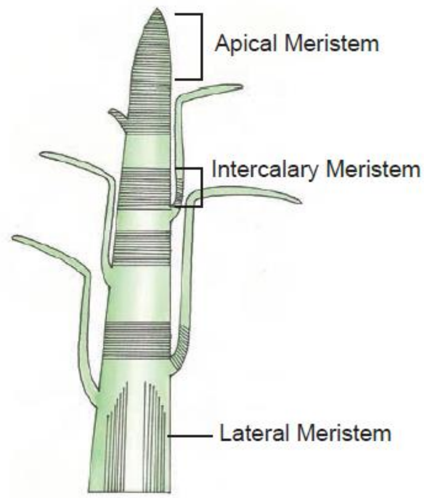
Meristematic Tissues

The growth of plants occurs only in certain specific regions. This is because the dividing tissue, also known as meristematic tissue (Meristos – divisible), is located only at these points.

Meristematic tissues are made up of groups of similar and immature cells, which can divide and form new cells. Meristematic cells divide continuously and help in increasing the length and thickness of the plant. Depending upon their position, meristematic tissues can be of three types. They are as follows:

i) **Apical meristems:** Apical meristem is present at the growing tips of stems and roots and increases the length of the ***I DO*** plant body.

ii) **Intercalary meristems:** These meristems occupy the base of leaves and the base of internodal regions in plants such as grasses (mostly in monocotyledonous plants). These help in the elongation of the internodes.



Longitudinal section of a shoot showing position of meristems

iii) **Lateral meristems:** This includes the meristematic tissues that occupy the lateral regions of stems and roots. They bring about increase in the width of the plant body. (e.g. cork cambium and vascular cambium).

Characteristic features of meristematic tissues

- The meristematic cells may be round, oval, polygonal or rectangular in shape.
- Their cell walls are thin, elastic and made up of cellulose.
- They are closely arranged without any intercellular spaces.
- They have dense cytoplasm with large central nucleus.

What happens to the cells formed by meristematic tissues?

Transverse section of a sunflower stem

Some cells produced by meristematic tissues stop dividing and form permanent tissues.

Permanent Tissues

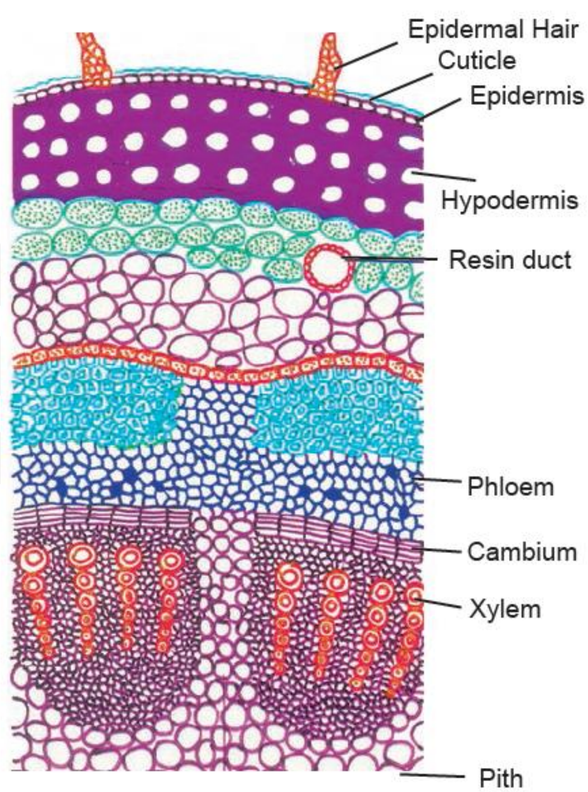
They have definite structure and function. They are differentiated into various types according to the different functions they perform.

Permanent tissues are classified as:

i) Simple tissues
ii) Complex tissues

Simple Tissues

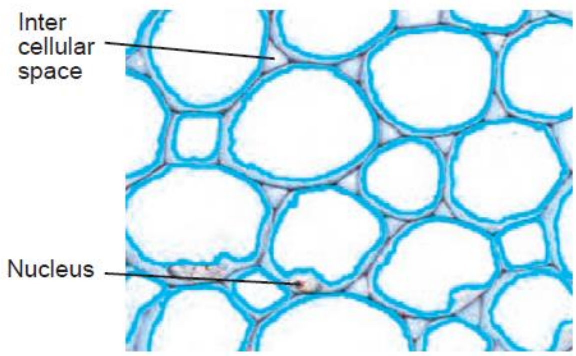
A tissue made up of cells having similar structure (one type of cells) and function is called simple tissue. They are of three types:
a. Parenchyma
b. Collenchyma
c. Sclerenchyma



Enlarged section of a sunflower stem

Parenchyma

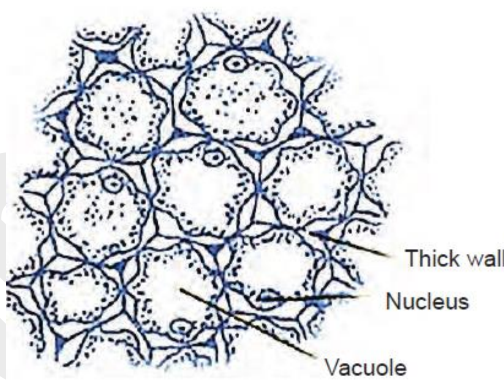
The cells of the parenchyma are generally thin-walled with intercellular spaces. They are living cells. They are present in all the organs of a plant. They may be oval, spherical, rectangular or cylindrical in shape. The cell wall is made of cellulose and pectin. Parenchyma cells serve to store and conduct food materials, water and minerals.



Parenchyma

Collenchyma

The cells of collenchyma are polygonal in cross-section and have unevenly thickened walls. These thickenings are due to the deposition of cellulose, hemicelluloses and pectin.



Collenchyma

The thickening is confined to the corners of the cells. They generally occur in the dicot stem in two or more layers below the epidermis. It is absent in the roots. It also occurs in the petiole and pedicel. Collenchyma is also a living tissue. The main function of the collenchyma is to provide strength and flexibility to the growing organs like the young stem.

Sclerenchyma

Sclerenchyma is a dead tissue. The cells are thick with lignified walls. They give mechanical support to the organs.

This has two types of cells-sclereids and fibres.

Sclereids : Sclereids are stone cells which are commonly found in the shells of the nut and pulp of certain fruits such as pear and sapota.

Fibres : Fibres are elongated strands with simple pits throughout its length.

Complex Tissues

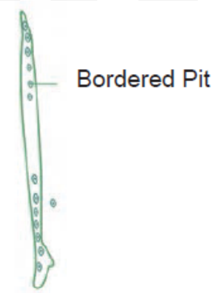
A tissue that consists of several kinds of cells but all of them function together as single unit is called complex tissue.

Xylem

Xylem is mainly concerned with the upward transport of nutrients, water and minerals in the plant body. It forms a continuous tube through the roots, stems, leaves, flowers and fruits by the fusion of elongated cells.

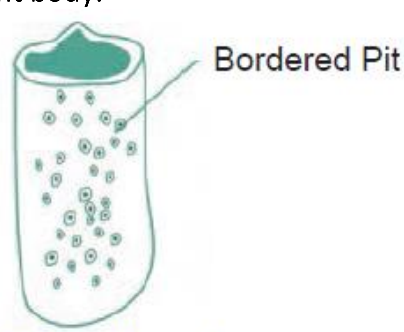
It is composed of different kinds of cells, namely:
a. Tracheids b. Xylem Vessels c. Xylem Fibres d. Xylem Parenchyma

a. Tracheids: Tracheids are elongated, tapering cells with blunt ends. They have a lignified secondary wall. They are the chief water conducting elements in Pteridophytes and Gymnosperms.



Tracheid

b. Xylem Vessels : Xylem vessels have perforations at the end and are placed one above the other like a long pipe-line. They are seen in the xylem of angiosperms. They conduct water, mineral nutrients and also provide mechanical strength to the plant body.

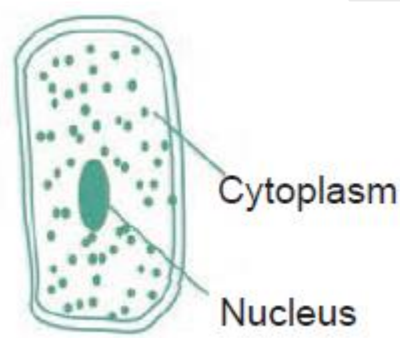


Xylem Vessel

c. Xylem Fibres : The fibres of sclerenchyma associated with xylem are known as xylem fibres. They give additional mechanical strength to the plant. They are also called as wood fibres.

Xylem Fibre

d. Xylem Parenchyma : The parenchyma cells associated with xylem are known as xylem parenchyma. It is the only living cell in the xylem tissue. They store food reserves in the form of starch and fat. They also help in conduction of water.



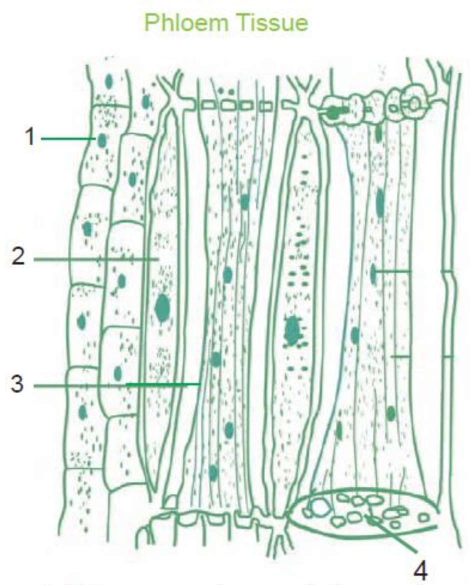
Xylem Parenchyma

Phloem Tissue

Phloem conducts food materials from leaves to the other parts of the plant. It is made up of four types of cells:

a. Sieve elements
b. Companion cells
c. Phloem fibres
d. Phloem parenchyma

a. Sieve Elements : Sieve elements are the conducting elements of the phloem. Sieve elements are of two types sieve cells and sieve tubes.



1. Phloem parenchyma 2. Companion cell 3. Sieve tube 4. Sieve plate

Sieve cells are present in Pterido- phytes and Gymnosperms whereas sieve tubes are present in Angiosperms.

b. Companion Cells: Companion cells are thin-walled, elongated, specialized parenchyma cells. They are associated with sieve elements. They have a prominent nucleus and cytoplasm. They help the sieve tube in conduction of food materials in angiosperms.

c. Phloem Fibres: The fibres of sclerenchyma associated with phloem are called phloem fibres. They are also called as bast-fibres. They give mechanical support to the plant. Among the four types of phloem cells, phloem fibres are the only dead tissues.

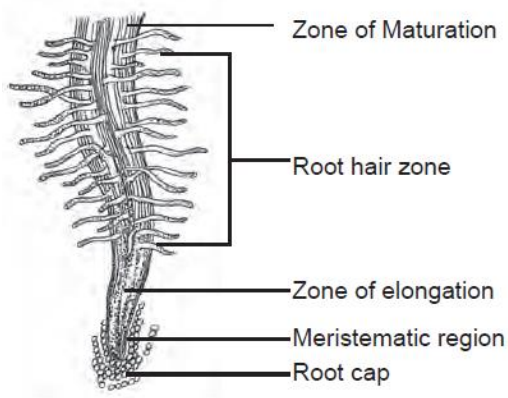
d. Phloem Parenchyma: The parenchyma cells associated with phloem are called phloem parenchyma. They store starch and fats.

1.3. PLANT FUNCTIONS

Plants germinate from seeds, grow, develop, mature, reproduce and die. They perform absorption, photosynthesis, respiration, transportation and transpiration. Plant physiology deals with how plants function.

Water is essential for all physiological activities of plants. It plays an important role in physiological activities like photosynthesis, respiration, transpiration and transportation.

The presence of water in the soil is essential for the normal functioning of plants. Soil water contains minerals in the dissolved state.



Regions of the Root

Plants absorb water and minerals from the soil with the help of root hairs. This process is called absorption. The three different forces involved in absorption are:

(i) Imbibition
(ii) Diffusion
(iii) Osmosis

i) Imbibition

Imbibition is the uptake of water by the substances that do not dissolve in water causing swelling of these substances. Eg.wood and seeds. These substances are called imbibants.

In plant cells, the cell wall is the imbibant. It absorbs water and forms a channel for movement of water into the cell by diffusion and osmosis.

Imbibition plays a very important role during germination. Seeds imbibe water through the seed coats. They swell and rupture, allowing the radicle and plumule to emerge.

ii) Diffusion

Dissolved molecules move from a region of higher concentration to a region of lower concentration until the molecules are evenly distributed throughout the available space. Gases such as oxygen and carbon-dioxide, and nutrients like minerals move into cells by diffusion.

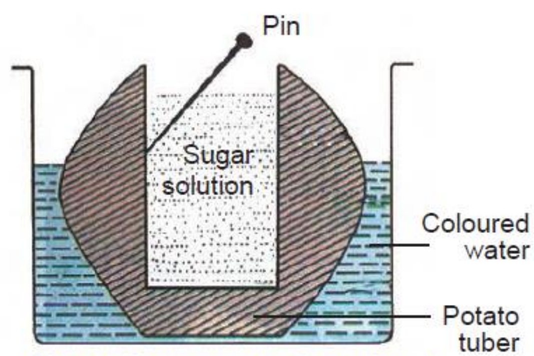
iii) Osmosis

The movement of water molecule from a region of higher concentration to a region of lower concentration through a semipermeable membrane is called osmosis.

Demonstration of Osmosis

A potato is taken and peeled. The base is cut to make it flat. A hollow cavity is made in the centre of the tuber and filled with sugar solution. The initial level of solution is marked with the help of a pin. It is placed in a beaker containing coloured water.

After sometime, it is observed that the sugar solution in the cavity of the potato becomes coloured and its level rises. How has this taken place? This is due to the entry of water from the beaker into the cavity of
the potato through the living cells of the potato. Here the living cells of the potato act as a semi-permeable membrane.



Potato Osmoscope Experiment

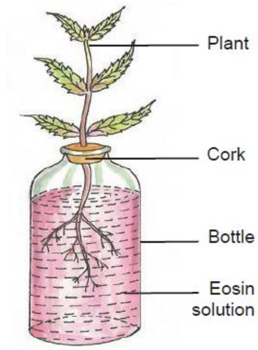
When substances move from a region of higher concentration to a region of lower concentration, without the use of metabolic energy, it is said to be passive transport. Active transport involves the use of metabolic energy for movement of molecules. The uptake of mineral ions is by active transport.

Ascent of Sap

Water, along with mineral salts, are absorbed by the root through its root hairs. The absorbed water reaches the xylem vessels and finally reaches the leaves. This movement of water and mineral salts
is known as ascent of sap.

Demonstration of Ascent of Sap

Take an entire balsam plant without damaging the roots. Wash the roots to remove the soil particles. Insert the roots into a bottle containing dilute eosin solution or red ink solution. Leave aside the set-up for sometime.



Ascent of Sap Experiment

After sometime, red streaks can be observed on the stem and veins of the leaves. If a section of the stem is mounted on a microscope and observed, it will show that only the xylem vessels are coloured, showing that ascent of sap takes place only through the xylem vessels.

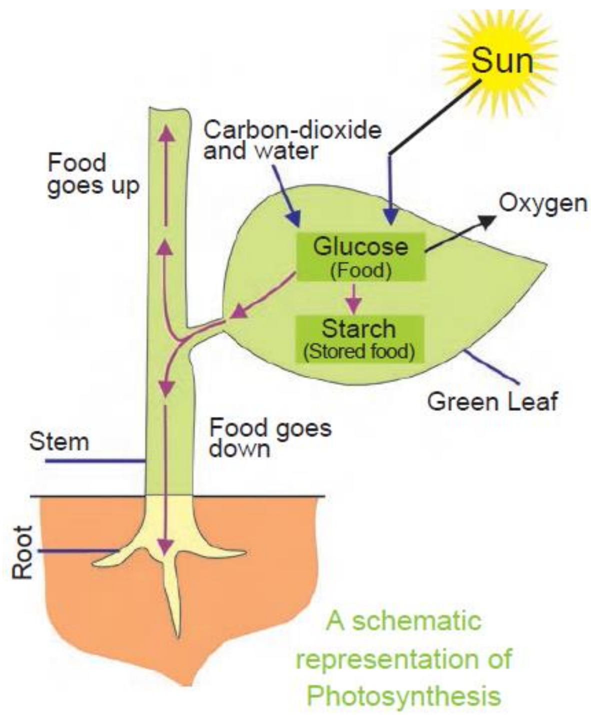
1.4. PHOTOSYNTHESIS

Green plants are autotrophic and synthesize their own food by the process of photosynthesis. ‘Photo’ means ‘light’ and ‘synthesis’ means ‘to build’. Thus ‘photosynthesis’ means ‘building up with light’.

Green leaves prepare food by combining carbon-dioxide and water in the presence of sunlight and chlorophyll.

Carbon-dioxide from the atmosphere enters leaves through tiny pores called stomata. Water taken from the soil is transported to the leaves through roots and stem. The green pigment called chlorophyll present in green leaves absorbs light energy. Sunlight provides the energy required to carry out the chemical reactions involved in the preparation of food.

The process by which green plants synthesize carbohydrate from carbon-dioxide and water by using energy from sunlight in the presence of chlorophyll is called photosynthesis. Oxygen is released during photosynthesis.



The leaf is a flattened, lateral outgrowth of the stem. The functions of the leaf are:
a) Photosynthesis - Synthesizing carbohydrate using sunlight energy, CO2 and water.
b) Respiration - Taking in oxygen and giving off CO2.
c) Transpiration - Giving out excess water as water vapour.
d) Food Storage - Leaves also serve as organs of food storage in some plants.
e) Vegetative Reproduction - Buds that can develop into new plants.

Mechanism of Photosynthesis

The process of photosynthesis occurs in two phases: (i) Light reaction (ii) Dark reaction

i) Light Reaction: The reaction involving chlorophyll, solar energy and water that produces ATP (Adenosine Tri-Phosphate) and NADPH2 (Nicotinamide Adenine Dinucleotide Phosphate-reduced form) is called light reaction.

ii) Dark Reaction: The reaction in which CO2 is reduced to carbohydrate with the help of ATP and NADPH2 generated during light reaction is called Dark reaction. Light is not required for this reaction. So it is called Dark reaction.

Overall equation:

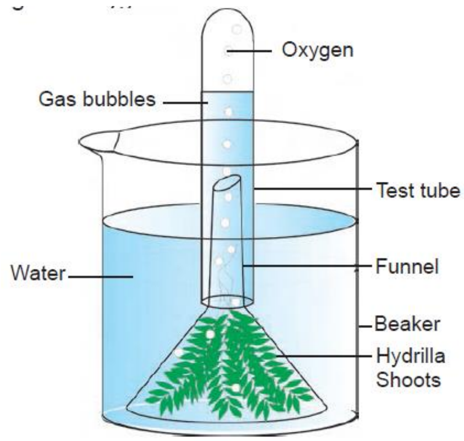
$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 \text{ (glucose)} + 6O_2$$

Experiment to show that oxygen is evolved during photosynthesis

Test Tube and Funnel Experiment

Aim: To show that oxygen is evolved during photosynthesis.

Procedure: Place a few cut branches of hydrilla in a beaker of water and invert a glass funnel over the cut branches in such a way that the cut end faces the stem of the funnel. The stem of the funnel should be below the level of water. A test tube is filled with water and it is inverted over the stem of the funnel.
A pinch of sodium bicarbonate is added to the water as a source of carbon-dioxide. The apparatus is kept in sunlight for 4 to 6 hours.



Test Tube and Funnel Experiment

Gas bubbles may be observed from the cut ends of Hydrilla branches. These gas bubbles are collected in the test tube by downward displacement of water. The gas is tested for oxygen. When a burnt splinter is taken near the mouth of the tube, it glows brightly. This proves that the gas is oxygen

This proves that oxygen is evolved during photosynthesis.

Factors Affecting Photosynthesis

Photosynthesis is influenced by various factors. They are light, temperature, carbon-dioxide, chlorophyll distribution, water, mineral salts and age of the leaf.

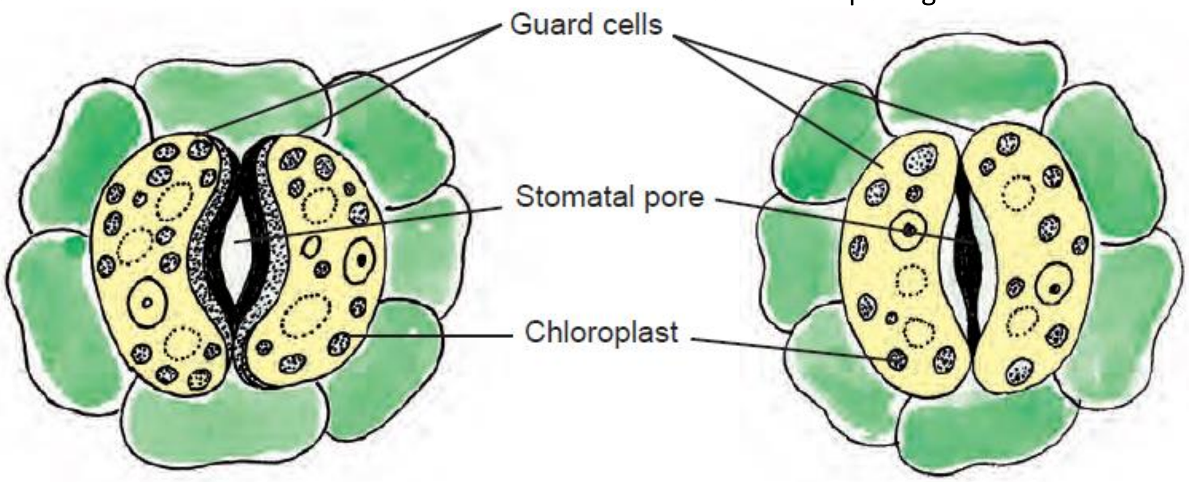
1.5. TRANSPIRATION

Plants absorb a large quantity of water and use only a fraction of it. The excess of water is removed through the aerial parts of the plant such as leaves and green shoots. This is called transpiration.
There are three types of transpiration:

i) Stomatal transpiration ii) Cuticular transpiration iii) Lenticular transpiration

Stomatal Transpiration

Stomata are tiny pores on the epidermis of leaves and other aerial parts of the plant like stem. Each stoma (singular of 'stomata') is bounded by two kidneyshaped cells that control the opening and closing of the pores. These are called guard cells. Each guard cell has an elastic thin outer wall and a thick inner wall. When the guard cells are turgid (full of water), the outer walls are stretched and the stomata remain open. This happens during the day. At night, the guard cells lose water to the surrounding cells and become flaccid. The inner walls come closer. This reduces the stomatal opening.



(a) Open Stomata (b) Closed Stomata

This loss of water through the stomata is called stomatal transpiration. When the stomata are open, the transpiration rate increases. When they are closed, the transpiration rate decreases. A large quantity of water is lost through the stomata during transpiration.

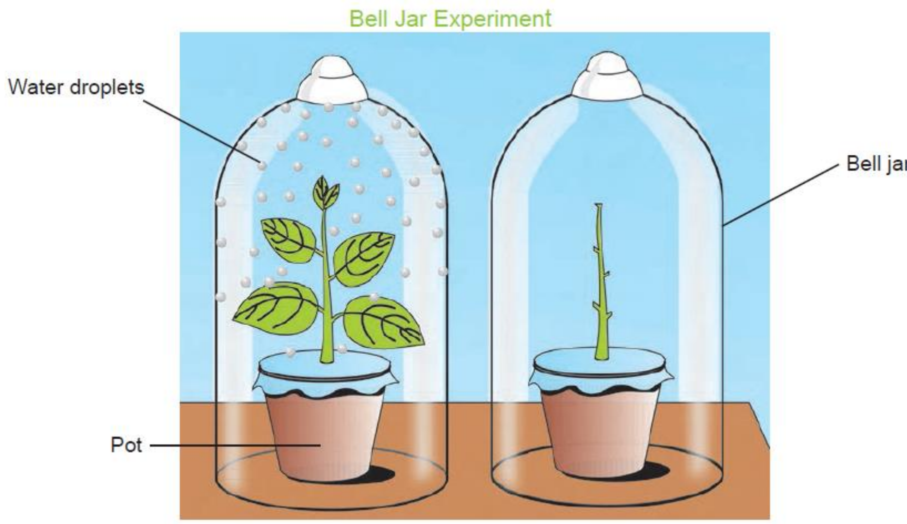
Cuticular Transpiration

Cuticle is found as a waxy layer on the epidermis of a plant. It serves as a barrier to water movement out of a leaf. The cuticle is made of wax and is very hydrophobic or 'water-repelling'. Water does not move through it very easily. The thicker the cuticle layer on a leaf surface, the slower the transpiration rate. Cuticle thickness varies widely among plant species. In general, plants from hot, dry climates have thicker cuticles than plants from cool, moist climates. In addition, leaves that develop under direct sunlight will have much thicker cuticles than leaves that develop in the shade.

Lenticular Transpiration

Lenticels are tiny openings that protrude from the bark in woody stems and twigs as well as in other plant organs. Loss of water through lenticels is called lenticular transpiration and it is a very small percentage compared to stomatal transpiration.

Experiment to show that transpiration takes place through the leaves



Aim : To show that transpiration takes place through leaves.

Procedure: Take two identical potted plants with broad leaves. Cover the surface of the pot with rubber sheet so that the soil is not exposed. In one plant, remove all the leaves and apply vaseline to the cut ends. Cover each potted plant with a dry bell jar. Leave this set-up for few hours. Observe what happens.

Droplets of water are seen on the inner surface of the bell jar which covered the plant with leaves, whereas no water droplets are seen in the other bell jar. The presence of water droplets proves that transpiration takes place only through leaves.

Factors Affecting Transpiration:

Light, temperature, wind, quantity of water in the soil, number of stomata and surface area of the leaf are the factors that affect transpiration.

1.6. RESPIRATION

Oxygen combines with glucose to bring about respiration. This process of release of energy from food is called respiration. All the energy required for life processes is obtained by the oxidation of food.

Mitochondria is the seat of biological oxidation.

Respiration is defined as a biochemical process consisting of oxidation and degradation of food with the release of energy.

The energy released during respiration is stored in the form of ATP (Adenosine Tri Phosphate) molecules in the cells and are used by the organism as and when required. ATP is known as the energy currency of the cell.

Types of Respiration

Oxidation of food can occur in the presence of oxygen as well as in the absence of oxygen. Based on this, there are two types of respiration.

i) Aerobic respiration (Aerobic - with air)
ii) Anaerobic respiration (Anaerobic - without air)

Aerobic Respiration

This type of respiration occurs normally in all plants. In this type of respiration glucose is completely oxidized in the presence of oxygen, releasing CO2, water and energy.

$$C_6H_{12}O_6\text{(glucose)} + 6O_2 \longrightarrow 6CO_2 + 6\,H_2O + 2900\text{ KJ energy}$$

Anaerobic Respiration : Organisms like bacteria and yeast undergo respiration in the absence of oxygen. It is called anaerobic respiration. In this type, oxidation of food material is incomplete.

$$C_6H_{12}O_6\text{(glucose)} \xrightarrow[\text{Zymase (enzyme)}]{\text{Yeast}} 2C_2H_5OH + 2\,CO_2 + 50\text{ KJ energy}$$

Factors Affecting Respiration

Oxygen, temperature, water, light, CO_2 and glucose are some of the factors that affect respiration.

1.7. TRANSPORTATION

The uptake and release of air, water, solutes and sap in plants involves transportation. It is a life process by which a substance, absorbed or made in one part of the body of an organism, is carried to the other parts of the body.

Due to the branching shape of a plant, all the cells of a plant can get oxygen for respiration and carbon-dioxide for photosynthesis directly from the air by diffusion.

Therefore the transport system primarily involves transport of water, minerals and food prepared in the leaves to the various parts of the plant.This is done through two specialized transport systems made of xylem and phloem cells.

The transport of materials in a plant can be divided into two parts:

i) Transport of water and minerals in the plant.
ii) Transport of food and other substances like hormones in the plant.

Transport of Water and Minerals

Water and minerals are absorbed from the soil by the roots of the plant and transported to the various parts of the plant like stem, leaves and flowers. Water, along with the minerals dissolved in it, moves from the roots to the other parts through the two kinds of xylem cells called xylem vessels and tracheids.

In pteridophytes and gymnosperms, tracheids are the only water conducting tissues.

In angiosperms either xylem vessels or both xylem vessels and tracheids transport water.

The movement of water and dissolved salts in the xylem is always upwards and it is caused by the suction of water at the top because of the low pressure created by transpiration from leaves.

Transport of Food and Other Substances

The transport of food from leaves to the other parts of the plant is called translocation. The movement of food materials through phloem depends on the action of living cells called sieve tubes.

Food is made in the mesophyll cells of a leaf. This enters into the sieve tubes of the phloem and is transported to all other parts of the plant body by the network of sieve tubes present inside the stem and roots.

The movement of food in phloem can be upwards or downwards or lateral depending upon the needs of the plant.

1.8. PLANT NUTRITION

Intake of nutrients into the body by an organism is called nutrition. All the nutrients required by organisms are obtained through the food they consume.

Organisms differ in their modes of nutrition. There are mainly two modes of nutrition:
i) Autotrophic nutrition
ii) Heterotrophic nutrition

Autotrophic Nutrition

In autotrophic nutrition, the organism synthesizes its own food. Organisms which are able to synthesize their own food materials are called autotrophs. They convert carbon-dioxide and water into various organic compounds with the help of energy. Depending on how the plants obtain energy for converting carbondioxide to organic compounds, they are classified as:

- Photo autotrophs
- Chemo autotrophs

Photo Autotrophs

All green plants are photo autotrophs. These are organisms which use energy from sunlight for the synthesis of food. Examples also include some bacteria like green sulphur bacteria, purple sulphur bacteria.

Chemo Autotrophs

Organisms which use chemical energy for the synthesis of carbon compounds are called chemo autotrophs. They get energy by oxidizing simple inorganic compounds such as hydrogen, sulphur containing compounds, hydrogen sulphide and ammonia. e.g. Nitrosomonas bacteria.

Heterotrophic Nutrition

Some organisms cannot synthesize their own food. They depend on other organisms for their food directly or indirectly. Organisms which are not able to synthesize their own food are called heterotrophs. Heterotrophic nutrition is of two types:

- Saprophytic nutrition
- Parasitic nutrition

Saprophytic Nutrition

Plants which obtain nutrition from dead or non-living organic matter are called Saprophytes. e.g. : Mucor (Fungus), Bacillus subtilis (Bacteria) and Monotropa (Angiosperm)

Parasitic Nutrition

In parasitic nutrition, an organism derives its food from the body of other living organism (host). These plants are called parasitic plants. They have special structures which penetrate the host and absorb food, water and minerals. These special structures are called haustoria. e.g. : Xanthomonas citri (bacteria) Cercospora personata (fungus) Cuscuta (angiosperm).

Symbiotic Nutrition

When two organisms live together, they exchange nutrients and are benefited mutually. Such type of nutrition is called symbiotic nutrition and the organisms are called symbiots. e.g. Lichen, Mycorrhiza and Rhizobium.

1.9. MOVEMENT IN PLANTS

Plants are fixed in a place with their roots in the ground. They lack the power of locomotion, but they can move individual parts or organs when subjected to external stimuli like light, water, chemical substances and touch.

These plant movements made in response to external stimuli fall into two main categories:

- Tropic movements
- Nastic movements

Tropic Movement

These are directional movements and are in response to stimulus, which comes mostly from one direction. The growth may be towards the stimulus or at the specific angle to the stimulus. Movement in which the direction of stimulus determines the direction of response is called tropism.

Depending on the types of the stimulus the tropic movement is classified as follows:

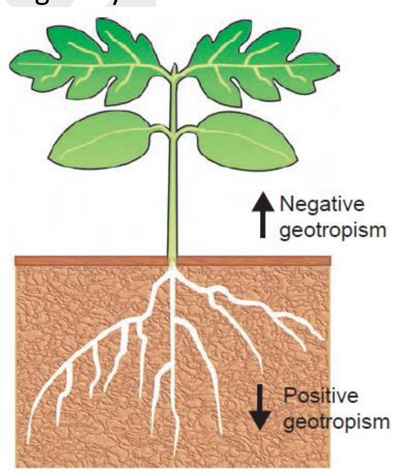
If the growth or movement of a plant part is towards the stimulus, it is called positive tropism. If the growth or movement of a plant part is away from the stimulus, it is called negative tropism.

Phototropism

The movement of a plant part in response to light is called phototropism. If the plant part moves towards the sunlight, it is called positive phototropism. If the plant part moves away from the sunlight, it is called negative phototropism. The stem always grows towards light and the root always grows away from sunlight.

Geotropism

The movement of plant part in response to gravity is called geotropism. If the plant part moves in the direction of gravity, it is called positive geotropism. If the plant part moves against the pull of gravity, it is called negative geotropism. Roots of a plant always grow downwards in the direction of gravity and the stem always grows the upwards against gravity.



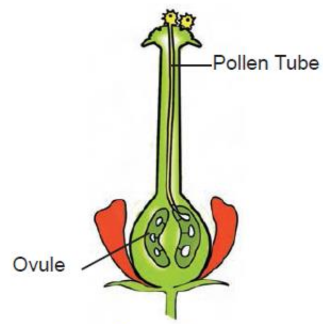
Geotropism

Some plants are capable of synthesizing food by photosynthesis but they are not able to synthesize proteins due to the deficiency of nitrogen. They overcome this deficiency by catching small insects and digesting them. Such plants are called insectivorous plants. e.g. Nepenthes and Drosera.

Stimulus	Type of tropism
Light	Phototropism
Gravity	Geotropism
Chemical	Chemotropism
Water	Hydrotropism
Touch	Thigmotropism

Chemotropism

The movement of a plant part in response to a chemical stimulus is called chemotropism. If the plant part moves towards the chemical, it is called positive chemotropism. On the other hand if the plant part moves away from the chemical, then it is called negative chemotropism. The growth (movement) of a pollen tube towards the ovule induced by a sugary substance as stimulus is an example of chemotropism. The ripe stigma in the carpel of a flower secretes a chemical substance (sugary substance) into the style towards the ovary. This sugary substance acts as a stimulus for the pollen grains which fall on the stigma.



Chemotropism

Hydrotropism

The movement of a plant part in response to water is called hydrotropism. If the plant part moves towards water, it is called positive hydrotropism. On the other hand if the part moves away from water it is called negative hydrotropism. The roots of a plant always go towards water and they are positively hydrotropic.

Thigmotropism

Climbing plants have weak stems. They cannot stand erect. They use thin threadlike climbing organs called tendrils. Tendrils are sensitive to touch or contact of other objects. When a tendril touches an object, then the side of the tendril in contact with the object grows slower than its other side.
This causes the tendril to bend towards the object by growing towards it, wind around the object and cling to it. The winding movement of the tendril of a climbing plant is an example for thigmotropism.

Nastic Movement

The movement of a plant part in response to an external stimulus in which the direction of response is not determined by the direction of stimulus is called nastic movement.
Some of the nastic movements are as follows:

i) Thigmonasty (Seismonasty) : The nondirectional movement of a plant part in response to the touch of an object is called thigmonasty. The best example for thigmonasty is Mimosa pudica (Touch-me-not plant). If we touch the leaves of the sensitive plant, then its leaves fold up and droop immediately.

Before touch

After touch

Mimosa pudica (Touch-me-not plant)

ii) Photonasty: The non-directional movement of a plant in response to light is called photonasty. The opening of leaves and flowers during the day and their closure at night is an example. A dandelion flower opens up in the morning in bright light but closes in the evening when the light fades and it gets dark.

iii) Thermonasty: The non-directional movement of a plant in response to temperature is called thermonasty. In crocus, the flowers open at high temperature and close at low temperature.

1.10. SENSITIVITY IN PLANTS

When we touch the leaves of mimosa pudica, the leaves fold up. The petiole of mimosa pudica leaves have a padlike swelling at their base. This is called a pulvinus. It contains more water than the other cells around it. They create an internal pressure that holds the leaves upright. When the leaf is touched it creates an electric impulse that acts on the plant hormone. This causes the water to migrate from the cells of the pulvinus into the intercellular spaces. This loss of water forces the leaf to fold and droop. This water diffuses back after a brief period of 15 to 30 minutes, and the leaf returns to its original position.