What are Life Processes?

Life Processes are those basic functions of living beings which are essential for their survival. They are the same in all types of living forms whether unicellular or multicellular, plants or animals.

1. **Maintenance:-** All living beings are made of protoplasmic structures. They have to be kept in functional state whether an organism is active or inactive. Functional state of protoplasmic structures is maintained only if they are kept in dynamic state with breakdown and build-up processes going on simultaneously.
2. **Metabolism:-** It is the sum total of all chemical reactions which occur in a living being due to interaction amongst its molecules. All functions of organisms are due to metabolism. Metabolism has two components, anabolism and catabolism. Anabolism or constructive metabolism consists of build-up reactions where complex molecules are formed from simpler ones, e.g., formation of glycogen from glucose or proteins from amino acids. Energy is required for anabolic reactions. Catabolism or destructive metabolism consists of breakdown reactions where complex substances are broken down into simpler substances, e.g., respiration (breaks glucose into carbon dioxide and water).
3. **Nutrition:-** It is required by all living beings for providing energy and body building materials. Body building materials are usually carbon based so that food sources are also carbon based. Plants manufacture their own food in the process of photosynthesis. Animals obtain food from outside. Food obtained from outside is first broken down into simpler soluble substances for absorption. Inside the cells, the simple substances are converted into various complex bio-chemicals to form components of protoplasm.
4. **Respiration:-** Every living being requires energy for working of body machinery, its maintenance, repair, replacement and bio-synthesis. Energy is obtained by break down of carbon based molecules in the process of respiration. Oxidation-reduction reactions are common chemical reactions involved in respiratory break down of molecules. Most organisms use oxygen obtained from outside for the process of respiration.
5. **Growth:-** It is irreversible increase in body cells that occurs in young organisms prior to reaching maturity. Plants have the ability to continuously grow. Growth is possible if buildup reactions (Anabolism) are more abundant than break down reactions (Catabolic reactions). For this, the organisms must prepare or obtain food materials more than their requirement for maintenance.
6. **Exchange of materials:-** There is a regular exchange of materials between the living organisms and their environment. Living beings obtain nutrients, water and oxygen from their environment. They give out undigested materials, carbon dioxide and waste products. Single-celled organisms have the entire surface in direct contact with the environment. They do not possess any specific structures for intake and explosion of materials. Diffusion, facilitated transport and active transport are involved for movement of substances across the cell membrane.

   In multicellular organisms specialized structures have been formed for different functions e.g., ingestion, egestion, exchange of gases
7. **Transportation:-** In multicellular organisms, all the cells are not in direct contact with the environment. They have specific structures for exchange of gases, ingestion and digestion of food materials. However, every cell of the body has to be provided with food, water and oxygen. Similarly, carbon dioxide and wastes have to be taken away from every cell. Therefore, a mechanism of transportation is found. It is circulatory system in animals and vascular tissues in plants.
8. **Excretion:-** A number of waste products are formed as byproducts of metabolism. They are usually toxic and are removed from the body. The process of removal of waste products from the body is called excretion.

9. **Irritability:-** Every living organism is aware of its surroundings. It responds to changes in the environment.

NUTRITION:- may be defined as a collective phenomenon in which an organism is capable of capturing food essential not only for maintaining vital life processes, but also for repair and growth of tissues. The whole process of nutrition involves introduction of food, its digestion by various juices and enzymes and break down into smaller simpler and soluble molecules, absorption of the soluble food and lastly expulsion of undigested matter formed during the process. **MODES OF NUTRITION:** - The nutrition of all the organisms may broadly be grouped into three categories, which are:-

a) **Autortopic Nutrition Or Holophytic:-** It is a mode of nutrition in which organisms are able to build up their own organic food from inorganic raw materials with the help of energy. The organisms performing Autotropic nutrition are called Autotrops, Auto meaning self and trophe meaning nourishment. Autotropic nutrition is a characteristic feature of all the green colored pigments called as chlorophyll. These plants have an ability to synthesise all the essential organic compounds. From inorganic compounds like CO2 and H2O in presence of sunlight with the help of a process called Photosynthesis. Some animals, that contain chlorophyll in their bodies also, show this property of synthesizing their own food material eg; Euglena and some green bacteria like sulphur and methane bacteria.

b) **Heterotrophic Nutrition:** - It is a mode of nutrition in which organisms obtain readymade organic food from outside source. The organisms that depend upon outside sources for obtaining organic nutrients are called heterotrophs, (hetero or heteros and trophe meaning nourishment). It is a characteristic feature of all animals and non green plants, that are unable to utilize carbon and synthesis organic compounds necessary for life, but depends upon organic sources of carbon. They are thus dependent upon autotropic organisms (Plants) and are called as heteriotrophs. It is of the following types:-

1) **Saprophytic Nutrition:-** In this type of nutrition, an organism lives upon dead organic sources such as dead plants and dead animals. These usually secrete dissolving and digesting enzymes and absorb the liquidified molecules so formed e.g.; yeast, bread moulds and dung moulds etc.

2) **Parasitic Nutrition:-** In this type of nutrition, an organism lives totally at the expense of others and derives its food material and shelter from the other .These organisms which derive food material are called parasites and the organism from which food is derived is called as host. This type of nutrition is termed as parasitic or holozoic nutrition .It is also known as parasite-host relationship e.g. Cuscuta, Ascaris etc.

3) **Holozoic Nutrition:-** It is a mode of heterotrophic nutrition which involves intake of solid pieces of food. Since solid food is taken in, Holozoic nutrition is also called ingestive nutrition. Holozoic nutrition (GK. Holo-Whole, Zoon-Animal) is found in animals and protozoan protists. The food may consist of another animal, plant or its parts. Depending upon the source of food, Holozoic organisms are of three types- Herbivores, Carnivores, Ominivores.

Steps in Holozoic Nutrition:-

There are five steps in Holozoic nutrition- ingestion, digestion, absorption, assimilation and egestion.

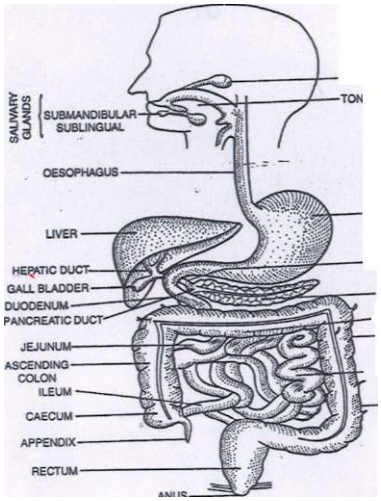
1. **Ingestion (L. ingestus-taken in.):-** It is taking in of solid food with the help of temporary or permanent mouth. Different animals use different organs for catching, holding and putting the food into mouth. Cutting and tearing the solid food into small pieces is common for ingestion.
2. **Digestion:-** The ingested food consists of complex insoluble organic substances. The conversion of complex insoluble food ingredients into simple absorbable form is called digestion. It is a catabolic process which occurs with the help of digestive enzymes.
3. **Absorption:-** The digestive food is absorbed from the digestive tract and transported to all body parts. It is picked up by all the living cells.
4. **Assimilation:-** Inside the living cells, the absorbed food materials are used in obtaining energy and formation of new components for repair and growth of cells. Assimilation is an anabolic process as it takes part in synthesis of proteins, polysaccharides, fats and other macromolecules.

5. **Egestion:-** (L. egestus-discharge) The whole of ingested food is seldom digested. The undigested components of food are thrown out of the body as faecal matter. The process is called egestion.

Autotrophic Nutrition	Heterotrophic Nutrition
Food is self manufactured.	Food is obtained readymade from outside.
An external source of energy is required for synthesis of food.	An external source of energy is not required. The required energy is present in the food obtained from outside.
Inorganic substances constitute the raw materials for manufacturing food.	Inorganic substances are not much required.
Digestion is absent.	An external or internal digestion is required for conversion of complex organic materials into simpler and soluble ones.
Chlorophyll is present for trapping light energy.	Chlorophyll is absent
Organisms performing autotrophic nutrition function as producers. Examples:- Green plants, Some bacteria, Some protists.	Organisms performing heterotrophic nutrition function as consumers. Animals, Many protists and Monerans.

Digestion:-

Digestion may be defined as hydrolysis of complex organic molecules with the help of enzymes into their simpler and diffusible component which can be absorbed in the gastrointestinal tract for further utilization. Thus it includes both mechanical and chemical breakdown of the ingested food material. It starts in the mouth and continues into small intestines. **TYPES OF Digestion**



Digestion is of two types: - Intracellular and Extracellular

1) **Intracellular Digestion:** - In unicellular organisms like Amoeba the food is taken through its surface (Endocytosis) and the digests it within the cell. This type of digestion occurring with in the cell is known as Intracellular Digestion.

2) **Extracellular or Intercellular Digestion:-** In higher multicellular organisms the food is put into a cavity or canal called alimentary canal or digestive tract or Gut or GIT where food is digested and then absorbed into the blood to reach the different parts of the body for proper utilization. The undigested food if any is passed out of the body through the other end of the alimentary canal. This type of digestion (outside the cell) is known as Extracellular or Intercellular digestion.

DIGESTION IN MAN Digestion of food material ingested by a man does not takes place in a particular region of the digestive tract or alimentary canal .It is completed in different parts which may be described as under

1. **Digestion of food in mouth:-** (buckle cavity) In man the process of digestion starts in the mouth which prepares food material for the digestion. In mouth, the teeth start breaking down food by the process of mastication. During this process the food is thoroughly mixed with saliva secreted by the salivary glands .It contains large number of enzymes, of which salivary amylase (ptyalin) is of great importance, causing chemical digestion of starch .The masticated and partially digested food is then rounded off in a form of small ball called as bolus with the

help of tongue and is passed through the esophagus or food pipe or gullet into the stomach by the peristaltic movements of the esophagus

2. **Digestion in stomach:-** In the stomach, the partially digested food material is acted upon by gastric juice secreted by gastric glands, containing HCL, pepsin, rennin, and gastric lipase enzymes. The gastric juice is a composite secretion of at least three different types of cells - parietal cells, chief cells and mucous cells. The parietal cells secrete HCL, The chief cells supply pepsin and other enzymes like rennin etc. and the mucous cells secrete mucin in the stomach pepsin breaks down the proteins into smaller molecules known as peptidase. The process is aided

by the addition of HCL, which not only activates the various enzymes but also turns the food into soup called chyme. This chyme passes into the duodenum for further action.

3. **Digestion in small intestine:-** In the anterior part of the small intestine called duodenum, the food (chyme) is mixed with the bile juices from liver, pancreatic juice from pancreas and intestinal juice from the intestinal glands. The combined effect of these juices causes the chief chemical changes of the intestinal digestion. These juices contain enzymes, which digest carbohydrates, proteins and fats of the food material. The broken food material is then diffused through the epithelial cells of the intestinal villi (finger like projections of the intestine) into the blood vessels which carries it to the cells.
4. **Digestion in large intestine:-** The process of the digestion does not take place in this region. It simply secrets mucus, which serves as a lubricant for easy passage of the undigested matter in the form of faeces. The intestinal walls also absorb water from the undigested food material passed into it which is ultimately egested through the anus.

Dental Caries: - It is localized softening and destruction of enamel and dentine of teeth forming cavities that reach the pulp. Dental caries is also called dental decay. It is caused by bacterium streptococcus mutans. It feeds on food particles especially sugars and produces acids. The acids are growing on food particles streptococcus mutans multiplies rapidly and forms a dental plaque. The plaque covers the teeth. Its bacteria secrete the acids that cause dental caries. Saliva which normally neutralises the acid and kills the bacteria is unable to protect the teeth because of the plaque. Brushing of teeth after meals removes the plaque. Bacteria are unable to multiply and produce acids. However, if plaque formation is allowed to persist, softening of enamel and dentine will allow the microorganisms to reach the pulp of the teeth. This results in inflammation and infection resulting in acute pain, total decay and falling of teeth.

Photosynthesis (Photos-Light, Synthesis-putting together)

Photosynthesis may be defined as an anabolic process in which green plants manufacture complex organic food substances (carbohydrate) from simple inorganic compounds like carbon dioxide and water in presence of sunlight with the aid of chlorophyll and evolve out oxygen as a byproduct of the process. Thus photosynthesis is a process in which radiant energy is converted into chemical energy

$$6C0_2+6H_20 \xrightarrow[\text{sunlight}]{\text{Chlorophyll}} C_6H_{12}0_6 + 60_2$$

In other words photosynthesis is a series of oxidation- reduction reaction in which $C0_2$ is reduced and H_20 is oxidized to produce carbohydrates and oxygen.

Mechanism of Photosynthesis:-

Photosynthesis is formation of organic food from carbon dioxide and water with the help of sunlight inside chlorophyll containing cells. Oxygen is produced as by-products.

$$6C0_2 + 12H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} \underset{\text{Glucose}}{C_6H_{12}0_6} + 6H_2O + 60_21$$

Oxygen comes from water. Hydrogen of water is used to reduce carbon dioxide to form carbohydrate.

$$2H_20 \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} 2H_2 + 0_2$$

$$\underset{\text{Carbohydrate}}{C0_2} + 2H_2 \xrightarrow{\text{Energy}} [CH_20] + H_2O$$

Actually, photosynthesis occurs in two steps, photochemical and biochemical.

1. **Photochemical phase (Light or Hill Reaction)** The reactions of this phase are driven by light energy. They are of two steps- photolysis of water and formation of assimilatory power.

a. **Photolysis of water:-** Light energy splits up water into two components. The step requires an oxygen evolving complex (formerly called z-complex) having manganese ions. Calcium and chlorine are also required.

$$2H_2o \xrightarrow[Mn, Ca, Cl]{OEC} O_2 + 4H^+ + 4e^-$$

b. **Formation of Assimilatory power:-** Electrons released by photolysis of water are picked up by chlorophyll a molecules. On absorption of light energy, each chlorophyll a molecule throws out an electron with gain of energy. This is primary reaction of photosynthesis which converts light energy into chemical energy. Electrons travel along an electron transport system, releasing energy in the process. The energy is used in the formation of ATP (adeno sine triphosphate) from ADP and inorganic phosphate. Synthesis of ATP and ADP and inorganic phosphate (pi) with the help of light energy is called Phototophosphory lation.

ADP + Pi + energy -------- ►ATP

The electrons ultimately activate NADP (nicotinamide di nucleotide phosophate) and makes it combine with hydrogen to form NADPH2.

$NADP^+ + 2e^- + 2H^+$-------- ► NADPH + H^+ ($NADPH_2$)

Both ATP and NADPH2 together form assimilatory power

2. **Biosynthetic phase (Dark or Blackman's Reaction):-** It is actually light independent reaction which can occur both in light as well as in dark. It requires the energy and reducing power contained in assimilatory power of light reaction. Common pathway of biosynthetic phase is calvin cycle. Carbon dioxide combines with ribulose biphosphate in the presence of enzyme ribulose biphosphate carboxylase or rubisco. It produces two molecules of phosphoglyceric acid (PGA).

$$RuBP + CO_2 \xrightarrow{rubisco} 2PGA$$

In the presence of ATP, phosphoglyceric acid is reduced by NADPH2 to form glyceraldehydes phosphate (GAP).

PGA + ATP + $NADPH_2$ ------- ► GAP + NADP + ADP + Pi

A part of glyceraldehydes phosphate is changed into dihydroxyacetone phosphate. The two condense and form glucose. Ribulose biphosphate is regenerated to combine with carbon dioxide again. Glucose undergoes condensation to form starch.

Raw material of the photosynthesis:-

The process of photosynthesis require various raw materials essential to synthesize energy complex compounds called carbohydrates. These include

(1) Chlorophyll:-

The chlorophyll or green pigment of the plant are the most active and important pigments of the photosynthesis. These are regarded as key pigments of the photosynthesis because of their remarkable ability of absorbing light energy, which is then converted into chemical energy during the process of photosynthesis. All the green plants contain chloroplasts, which give the coloring material and are accordingly called as photosynthetic- organelles of the plants.

(2) CO2:- All green plants utilize free atmospheric carbon dioxide during the process of photosynthesis to synthesis energy rich complex organic molecules called carbohydrates. These photosynthetic plants fix free atmospheric carbon dioxide during daytime when light energy is available to them. But during the night, the process stops.

(3) Water:- Water is another raw material for the process of photosynthesis. Plants absorb the required amount of water by root hairs and pass it on to the leaves through xylem, where it is utilized during the process of photosynthesis to synthesis energy organic compounds.

(4) Light:- The sunlight is a natural and prime source of energy for photosynthesis. It has been verified by experiments that the rate of photosynthesis remains highest in red light. Ordinary light consists of seven colors (VIBGYOR) and during photosynthesis; chlorophyll does not use all the seven colors. It absorbs mostly red and violet portions only. However, the green color reflects back which gives chlorophyll a greenish appearance.

Activities to demonstrate:-

1) **Importance of Chlorophyll:-** Take a variegated leaf of a garden plant that has been exposed to sunlight for few hours. Test it for starch with iodine test. Only green parts of the plant leaf will turn blue, showing that chlorophyll is necessary for photosynthesis.
2) **Importance of Light:-** Take a destarched potted plant, which has been kept in dark for 3 to 4 days. Cover one of its leaves completely with a carbon paper so that no light falls on it. Keep the plant in light for 4 to 6 hours. Test the covered leaf and uncovered leaf for starch with iodine test. The covered leaf will show negligible amount of starch, while the uncovered leaf will give positive test for starch. The process clearly shows that light is necessary for photosynthesis.
3) **Necessity of Carbon dioxide**:-Take two de starched potted plants and cover them with transparent polythene bags, so that no fresh air enters into them. Keep NaoH (Soda lime) that would absorb Co_2 in one pot and NaHCo (Sodium Bi-Carbonate) solution that would produce more Co_2 in the other pot. Keep both the pots in the sunlight for 4 to 6 hours and test one leaf from each for starch. The leaf from the first Pot will show no starch due to the absence of Co_2, while the leaf from the second pot will give positive test for the starch, thereby showing that Co_2 is necessary for photosynthesis.
4) **Evolution of oxygen:-** Take a beaker filled with water . Add a pinch of baking soda (NaHC03) to it and put a Hydrilla plant (Aquatic plant) in it. Cover the plant with a funnel. Invert a test tube containing water over the stem of the funnel. Keep this apparatus in the bright sunlight. After some time bubbles start emerging out from the plant, which gets collected in the upper part of the test tube. Remove the test tube and test the gas with a lighted splinter, it keeps on glowing showing that the gas is a supporter of combustion. Thus, the experiment clearly shows that O_2 is evolved during photosynthesis.

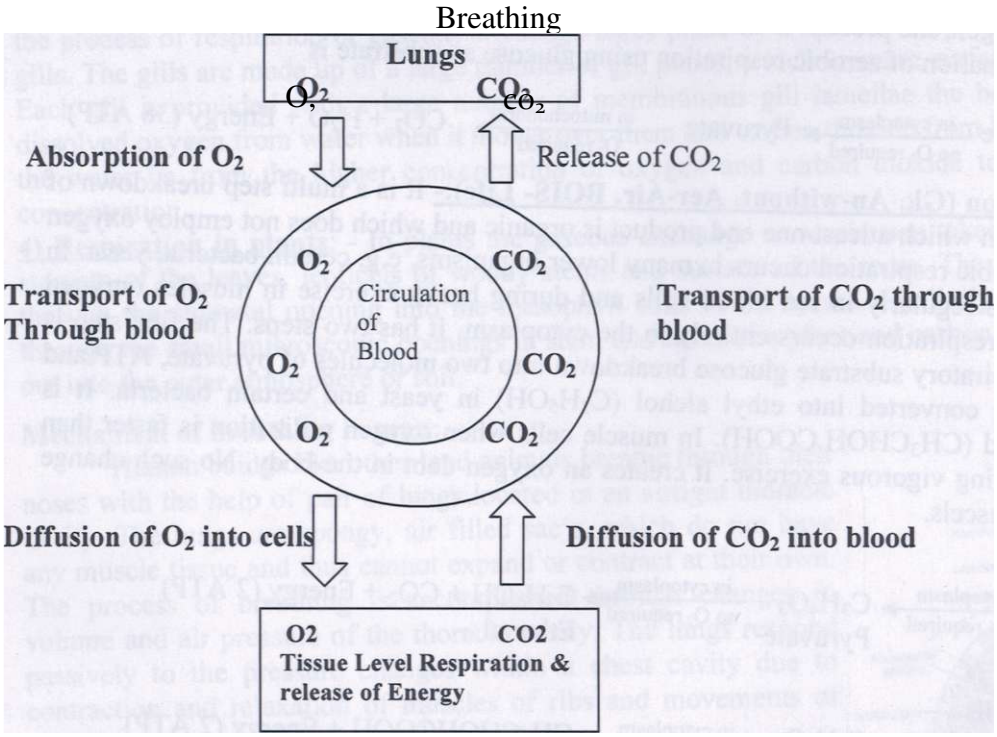
RESPIRATION

Respiration is a biochemical process of stepwise oxidative breakdown of organic compounds inside living cells releasing small packets of energy at various steps. Respiration is an essential physiological activity of all living organisms by which they obtains energy for carrying out various vital metabolic activities of the body. However, it is a chemical activity taking place within the protoplasm of a cell, which results in the liberation of energy. Energy liberated during oxidative breakdown of respiratory substrate is partly stored in ATP. The rest is dissipated as heat. The process of respiration involves the following steps.

$$C_6Hi_20_6 \xrightarrow{\text{enzymes}} 6C0_2 + 6H_20 + 38\ ATP$$

1) **External Respiration or Breathing:-** It refers to those mechanism by which air is brought into the body from the atmosphere and expulsion of Co_2 from the body into the atmosphere. The exchange of the gases takes place at the respiratory surface such as gills, tracheae or lungs.
2) **Transport of Respiratory gases:-** This phase involves transport of oxygen from respiratory surface to the body tissue_Co_2 from the tissues to the respiratory surface. In higher animals it takes place mainly through blood.
3) **Internal or Tissue Respiration:-** This phase of respiration involves consumption of oxygen by the body cells and production of Co_2 as a result of oxidative processes resulting in the liberation of energy necessary for the biological work of the body.
The distinct phases of respiration are represented in the diagram.

Aerobic and Anaerobic Respiration:- Sachs (1890) discovered that respiration can occur with or without oxygen. Therefore, there are two types of respiration, aerobic and anaerobic.



Aerobic Respiration (Gk. Aer-air, bios-life)

It is a multistep complete oxidative breakdown of respiratory substrate into carbon dioxide and water with the help of oxygen acting as a terminal oxidant. Aerobic respiration is the usual mode of respiration in all higher organisms and most of the lower organisms. The reason is that it yields maximum amount of energy.

$$C_6H_{12}0_6 \xrightarrow{\text{enzymes}} 6C0_2 + 6H_20 + 686 \text{ kcal or } 2870 \text{ kj}$$

The energy is stored in some 38 molecules of ATP. Aerobic respiration occurs in two steps, glycolysis and Krebs cycle.

Glycolysis (Gk. Glykys- sugar, lysis-breakdown):- Glycolysis or EMP (Embden, Meyerhof and parnas) pathway is the first step of respiration which is common to both aerobic and anaerobic modes of respiration. It occurs in cytoplasm. Respiratory substrate is double phosphorylated before it undergoes lysis to produce 3-carbon compounds glyceraldehydes phosphate. $NADH_2$ and ATP are produced when glyceraldehyde is changed to pyruvate. The net reaction of glycolysis is:

$$C_6Hi_20_6 + 2ADP + 2Pi + 2NAD + \xrightarrow[\text{in cytoplasm}]{\text{enzymes}} 2C_3H_4O_3 + 2ATP + 2NADH_2$$

Krebs Cycle (Krebs, 1940):- It is also known as citric acid cycle or tricarboxlic acid cycle (TCA cycle). Pyruvic acid or pyrovate enters mitochondria. It undergoes oxidative decarboxylation to produce acetyl CoA, carbon dioxide and NADH2. Acetyl CoA enters Krebs cycle. Here two decarboxylation, four dehydrogenations and one phosphorylation or ATP synthesis occur.

$$\text{Pyruvate} + NAD^+ + CoA \xrightarrow[\text{decarboxylation}]{\text{oxidative}} \text{Acetyl CoA} + NADH_2 + Co_2$$

$$\text{Acetyl CoA} + 2C0_2 \xrightarrow[\text{Krebs cycle}]{\text{enzymes}} 3NAD^+ + FAD \rightarrow CoA + 3NADH_2 + FADH_2 +$$

$NADH_2$ and $FADH_2$ liberate electrons and hydrogen ions. They are use in building up ATP molecules and activating oxygen molecules to combine with hydrogen for forming water. Water formed in respiration is called metabolic water. As oxygen is used at the end of Krebs cycle for combining with hydrogen, the process is called terminal oxidation.

The overall equation of aerobic respiration using glucose as substrate is

$$\text{Glucose} \xrightarrow[\text{no } O_2 \text{ required}]{\text{in cytoplasm}} \text{pyruvate} \xrightarrow[O_2 \text{ required}]{\text{in mitochondria}} CO_2 + H_2O + \text{Energy (38 ATP)}$$

Anaerobic Respiration (Gk. An-without, Aer-Air, BOIS- Life):- It is a multi step breakdown of respiratory substrate in which atleast one end product is organic and which does not employ oxygen as an oxidant. Anaerobic respiration occurs in many lower organisms, e.g. certain bacteria, yeast. In human body it occurs regularly in red blood cells and during heavy exercise in muscles (striated muscles). Anaerobic respiration occurs entirely in the cytoplasm. It has two steps. The first step is glycolysis. Here, respiratory substrate glucose breakdown into two molecules of pyruvate, ATP and $NADH_2$. Pyruvate is converted into ethyl alchol (C_2H50H) in yeast and certain bacteria. It is changed to lactic acid ($CH_3CHOH.COOH$). In muscle cells when oxygen utilization is faster than its availability as during vigorous exercise. It creates an oxygen debt in the body. No such change occurs in blood corpuscels.

In Yeast

$$\text{Glucose} \xrightarrow[\text{no 02 required}]{\text{in cytoplasm}} \underset{\text{Pyruvate}}{C_3H_4O_3} \xrightarrow[\text{no 02 required z}]{\text{in cytoplasm}} \underset{\text{Ethanol}}{C_2H_5OH} + C0_2 + \text{Energy (2 ATP)}$$

In Muscle cells

$$\text{Glucose} \xrightarrow[\text{no 02required}]{\text{in cytoplasm}} \underset{\text{Pyruvate}}{C_3H_4O_3} \xrightarrow[\text{no 02required}]{\text{in cytoplasm}} \underset{\text{Lactic Acid}}{CH_3CHOHCOOH} + \text{Energy (2 ATP)}$$

Difference between Aerobic and Anaerobic Respiration

Aerobic Respiration	Anaerobic Respiration
It is common method of respiration	It occurs permanently only in few organisms. In other it may occur as a temporary measure to overcome shortage of oxygen.
It is completed in three steps-glycolysis, Krebs cycle and terminal oxidation	There are two steps-glycolysis and anaerobic breakdown of pyruvic acid
It requires oxygen	Oxygen is not required
Respiratory substrate is completely broken down	Respiratory substrate is incompletely broken down
They are inorganic	Atleast one end product is organic. Inorganic products may or may not be present
End products show little toxicity	The organic end product is generally toxic
It occurs partly in cytoplasm and partly in mitochondria	Anaerobic respiration is carried out entirely in cytoplasm. Mitochondria are not required
An electron transport chain is required	ETC is not required
It in release 686 kcal or 2870 kj of energy per mole of glucose	Energy liberated is 36-50 kcal or 150-210 kj per mole of glucose
The liberated energy is used in forming 36-38 ATP molecules per mole of glucose	The liberated energy is used in synthesis of 2ATP molecules.

Mechanism of Respiration:- There are different mechanisms for process of respiration in different form of organism. The mechanisms of respiration in some of organisms may be described as under:-

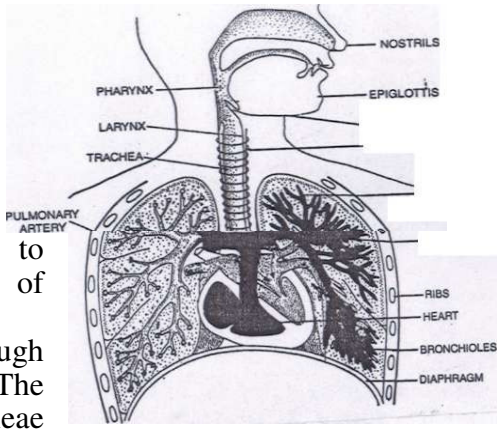
1. **Respiration in simple organisms:-** In the simplest forms of life like Amoeba, Euglena, Paramecium, Algae and Spirogyra, the respiratory gases may diffused in and out of the body through general body surface.
2. **Respiration in Insects:** - In insects, respiration of gases takes place through a system of internally air filled tubules called trachea. These opens into the exterior environment by paired

apertures called as spiracles these tissues carry air directly into the tissues of the body and bring out carbon dioxide out from them.

3) Respiration in aquatic animals: - In majority of higher aquatic animals like prawns and fish, the process of respiration or gaseous exchange takes place by a special respiratory organ called as gills. The gills are made up of a large number of gill plates, which increase surface area of the gills. Each gill is provided with a large number of membranous gill lamellae the bold of gills absorb dissolved oxygen from water when it mover over them and carbon dioxide from blood goes out into the water i,e from the higher concentration of oxygen and carbon dioxide towards their lower concentration.

4) Respiration in plants: - In plants the gaseous exchange or respiration takes place through the stomata of the leaves, lenticels of woody stems and surface of the roots. The diffused air passes through the stomatal opening into the mesophyll cells of the leaves. Similarly air is diffused inn through the small microscopic openings in stem and roots of a plant and carbon dioxide is diffused out into the outer atmosphere or soil.

Mechanism of breathing in man: -



Human beings like other land animals breathe through their noses with the help of pair of lungs located in an airtight thoracic cavity. The lungs are spongy, air filled sac's, which do not have any muscle tissue and thus cannot expand or contract at their own. The process of breathing is accomplished through changes in volume and air pressure of the thoracic cavity. The lungs respond passively to the pressure changes within a chest cavity due to contraction and relaxation of muscles of ribs and movements of diaphragm during inspiration and expiration.

In normal breathing, air enters into the nasal chamber through nose, where it is cleaned and warmed by the ciliated epithelium. The warmed and cleaned air then passes into the windpipe or tracheae through larynx and epiglottis. The tracheae at its lower portion bifurcates into two bronchi, each entering into a lung lobe, where a bronchus divides extensively by giving out various small branches called bronchioles. Finally the air is deposited in microscopic air sacs called alveoli. These are lined by a layer of epithelial cells and surrounded by a network of blood capillaries. The air in the lungs diffuses through the walls of these blood capillaries into the main blood stream and carbon dioxide in turn diffuses out into the lungs, where from it is expelled out into the external environment. This gaseous exchange is completed within a few seconds, while the blood is passed through the alveoli.

Diffusion: -The process of movement of molecules from one region to another in accordance to concentration gradient i.e., from the region of higher concentration to the region of lower concentration is called as diffusion. It takes place in all kinds of matter i,e solid, liquid and gas, but the process is faster in gases than solids or liquids.

The process of diffusion is a main method of transport of material in unicellular organisms like Amoeba, Euglena, Paramecium, Algae and Chlamydomonas etc. and some of the multicellular organisms like Sponges, Hydra etc.

Osmosis: - When two liquids of different densities are separated from each other by a selectively permeable membrane, the water of the liquids flows towards the liquid of higher density. This process in which water moves from a solution of lower density to the solution of lower density to the solution of higher density or from a dilute to a concentrated solution through a selectively permeable membrane is called osmosis.

Transportation:- is the movement of materials from one part to another, usually from the region of their availability to the region of their use, storage or elimination. Transporatation occurs in all organisms, from microscopic ones to large sized trees and animals.

Transport in plants: - Plants absorb sufficient quantity of water from soil by means of root hairs through the process of osmosis but they also take in minerals by the process of diffusion. Some part of this water is used up by the plant during various processes and the rest evaporates from the stem and roots. The evaporation of this surplus water from the aerial parts of a plant is known as transpiration.

In general, transpiration may be cuticular, lenticular or stomatal. The cuticular transpiration takes place through the cuticle found on the surface of the stem and leaves. The lenticular transpiration takes place through the lenticels found on the stem. The stomatal transpiration takes place through the stomata situated on the leaves.

It is through the process of transpiration, that the water along with dissolved mineral salts is taken up and transported up through the xylem. Evaporation of water from the leaves through stomata causes a drop in the turgor pressure, which makes the xylem cells to act as a single continues column and cause uptake of water from the soil.

Xylem (Wood)

It is a complex tissues which transports sap (water and minerals). Xylem has four types of cell-xylem fibres, xylem parenchyma, tracheids and vessels. Vessels and trancheids are called tracheary elements because they take part in transport of sap. Vessels are long multicellular tubes which are formed by end to end union of several cells. Trancheids are elongated cells with pointed ends. Both the tracheary elements have lignified walls with pits or other thin unlignified areas for element to element movement of water. Xylem parenchyma takes part in lateral flow of water. Trancheids are conducting elements of non-flowering plants. Vessels occur mostly in angiosperms where they form the main conducting elements. The number of tracheids is small in angiosperms. **Phloem**

It is complex tissues which takes part in transport of food. Phloem has four types of cells-sieve tubes, companion cells, phloem parenchyma and phloem fibres. Only phloem fibres are dead cells. Others are living cells. Sieve tubes are conducting channels of phloem. They are eleongated multicellular tubular channels formed by end to end union of numerous sieve tube elements. The end walls or septa between adjacent sieve tube elements are bulged out and have pores. They are called sieve plates. Sieve tube elements do not have a nucleus. Their functioning is controlled by adjacent nucleated companion cells.

Difference between Xylem and Phloem

Xylem	Phloem
Xylem is water or sap conducting plant tissue.	It is food conducting plant tissue.
Xylem has only one type of living cells.	It has three types of living cells.
Xylem has three types of dead cells-fibres, tracheids and vessel elements.	Phloem has only one type of dead cells, i.e., phloer fibres.
There are two types of conducting elements, tracheids and vessels.	There are only one type of conducting elements, i.e sieve tubes.
Vessels do not possess septa	Sieve tubes have porous septa called sieve plates.
Conduction is not influenced by metabolic inhibitors like heat, cold or poison.	Conduction is inhibited by heat, cold and poison.
Transport occurs due to presence of negative pressure.	Transport takes place due to presence of positiv pressure.

Transport of Water and Minerals:

There is a continous system of water conducting channels (vessels and tracheids) from near the root tips to near the shoot tips. In the roots the surface cells are in contact with soil particles and soil water. Ions and water are absorbed from the soil. They are pulled and pushed up by various forces to reach every cell requiring the same. The various steps involved in transport of water and minerals are as follows:

1. **Mineral Absorption:** It occurs in the growing parts of the root. Both the surface or epiblema cells as well as root hairs take part in mineral absorption. Mineral absorption is an active process which involves expenditure of energy. Being an active process, mineral absorption occurs against concentration gradient. It creates a difference in the concentration of ions between the roots and the soil, with more salts being present inside the root then in the soil StfMren.

2. **Absorption of water:** Root hair zone is the region of water absorption. The inside of the root has higher osmotic concentration than the soil solution. Root hairs are in contact with soil interspaces having capillary water. The root hairs pick up water which is transferred inwardly due to still high osmotic concentration. It reaches the cells surrounding the xylem channel. Salts accumulated in the basic part of xylem channel cause osmotic entry of water into xylem and form column of water. It also creates the positive pressure known as root pressure.
3. **Development of negative pressure:** Leaves and other aerial parts of the plant are continuously losing water in the vapour form in the process of transpiration. Nearly 99% of the absorbed water is lost during transpiration. Major part of transpiration is stomatal transpiration. Intercellular spaces of the leaves are in contact with mesophyll cells as well as outside air through stomata. Outside air is seldom saturated with water vapours while the intercellular spaces are nearly always saturated with water due to evaporation from the wet walls of mesophyll cells. Therefore, water vapours diffuse from intercellular spaces to outside. More water vapours come from mesophyll cells to replace them. The process continues. Loss of water by mesophyll cells increases their suction pressure. They withdraw water from the xylem channels. As there are billions of mesophyll cells withdrawing water from xylem channels, water column present in the xylem comes under tension or negative pressure.

Transport of food and other substances

Food materials are translocated from the region of their manufacture or storage to the region of their utilisation. The region of supply of food is called source while the area of utilisation is called sink. The direction of translocation can be downward, upward or both. The food manufactured by leaves spases into the storage region and other sinks in the downward direction as well as towards growing points and developing fruits in the upward direction. The translocating nutrients consist of soluble carbohydrates (mostly sucrose), amino acids, organic acids, harmones and other organic solutes. Translocation occurs thorough phloem. The channels of transport are sieve tubes (sieve cells in non flowering plants). Sieve tubes are specialised for this purpose. They are devoid of nuclei and internal membranes. The cytoplasm of one tube cells is continous with that of adjacent sieve tube cells through sieve plates. The force required for translocation is produced by companion cells which live adjacent to sieve tube cells.

Translocation:- Translocation is the movement of dissolved substances from one part of plant to another through the xylem in accordance to the concentration gradient of various mineral salts present in the soil.

Blood

Blood is described as a connective tissue, which provides one of the means of communication between the cells of different parts of a body and the external environment. It is a fluid containing living cells, which are capable of doing metabolic changes. It performs several vital functions of the body and hence is usually referred as the seat of the soul. Blood constitutes about 7% of the body weight (about 5.6 Lts in a 80 kg man). This proportion is les in women and considerable greater in children and gradually decreasing until the adult level is reached.

Composition of the blood: - Blood of higher animals including man is a viscous complex fluid tissue of red colour. It is made up of two main components viz.

1) Plasma:- Plasma represents an intercellular substance of straw colour. It constitutes about 55% of the total volume of the blood. Chemically plasma is composed of water (90 - 92%) plasma proteins, inorganic and organic in salts and a liquid called serum. It also contains a coagulative substance called fibrinogen and an anticoagulant called heparin or herudin.

2. Formed elements:- The cellular elements constitute about **45%** of the total volume of the blood. These are short and their destruction and replacement goes on constantly during the life of an animal. These include.

i) **Red blood cells of Erythrocytes:-** The erythrocytes are produced in the bone marrow of bones. Each erythrocyte is a round biconvex disc shaped, thinnest at the center having no nuclei at maturity. The average diameter of each erythrocyte is $10\sim^{6}$m. The individual erythrocytes are pale yellow in colour, but in aggregation they appear to be reddish in colour. Each erythrocyte is bounded by a thin

membrane composed of lecithin and cholesterol, enclosing an elastic substance called as stroma and an iron containing pigment called hemoglobin. The presence of hemoglobin- the red pigment serves as the carrier of oxygen. The average life span of erythrocytes is about 120 days in mammals, after this time they are disposed off either by liver or by spleen.

ii) White blood cells or Leucocytes:- White blood cells do not contain any pigment and are therefore colourless. They are larger, and fewer in number than the RBC's (1:600). They are formed in red bone marrow and in the lymph glands. The average life span of human leucocytes is about 12 to 13 days. The chief function of WBC's is to provide immunity to the body by producing special proteins called antibodies, which protects body against the infection of bacteria, viruses and debris etc.

The mature white blood cells are grouped in to two main categories, granulocytes or granular leucocytes and agranulocytes or angranular leucocytes depending upon the presence of visible granules in their cytoplasm. The granulocytes are in turn of three types viz. Eiosinophyll, Basinophyll and neutrophyll and the agranulocytes are of two types viz lymphocytes and monocytes.

iii) Blood platelets:- These are small, flat granular corpuscles or colourless cells, which are smaller than RBC. These are probably formed in the red bone marrow and contain a substance called thromboplast in which it acts as one of the enzymes involved in the series of chemical changes resulting in the clotting of blood at the site of an injury. The life span of these corpuscles is only 2-3 days. Hence these are constantly replenished by red bone marrow cells called as Megakaryocytes.

Function of Blood:- Blood has many functions, the most important ones are summarized as under:-

1. Transport of oxygen and carbon dioxide: - Blood transports oxygen from the respiratory surface and thus helps in respiration.

2. Transport of food: - Blood carries soluble food from the intestine to the liver and body cells, where it is required for cellular activities. The nutritive substances transported by the blood are glucose, amino acids, fats, minerals vitamins and water

3. Transport of waste products: - Blood transports various waste products, produced during the cellular activities of the body. These waste products are harmful and require immediate elimination.

4. Chemical Co-ordination:- Blood distributes various harmones to different parts of the body. These harmones are produced by the endocrine glands of the body and helps in the co-ordination of the body.

5. Maintenance of pH:- The plasma proteins of the blood act as buffer system and prevent any shift in the pH of the blood because of the amphoteric properties of these proteins.

6. Water balance:- Blood maintains water balance in the blood by bringing about constant exchange of water between the circulating blood and the tissue fluids.

7. Transport of heat: - Blood allows transfer of heat energy from the deeper tissue to the surface of the body.

8. Defense against infection:- Blood protects the body from various infections caused by the microorganisms like bacteria, viruses etc. with the help of WBC's.

9. Temperature Regulation: - Blood maintains the body temperature by distributing heat within the body.

10. Blood loss:- Blood prevents excessive loss of blood in an injury with the process of blood coagulation.

The Tubes-Blood Vessels

Human blood flows inside tubes caleed blood vessels. Blood vessels are of three types- arteries, veins and capillaries.

Arteries: They are blood vessels which carry blood coming from heart to various organs of the body. Blood flows inside the arteries with jerks due to pumping activity of the heart. As the blood is pumped into an artery, it expands. With the flow of blood from it, the artery contracts partially. Arteries, generally, carry oxygenated blood. Only pulmonary arteries transport deoxygenated blood from heart to lungs. The wall of the arteries is thick and elastic.

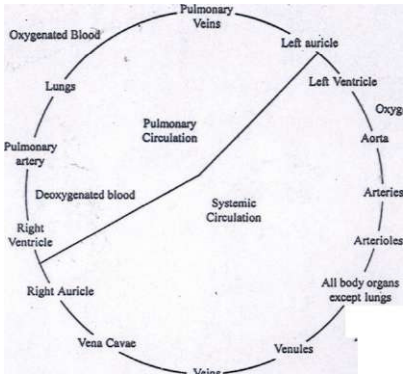
Veins: They are blood vessels which carry blood from various parts of the body towards the heart. Blood flows smoothly and slowly inside veins. Internal valves prevent back flow. Wall is less thickened and less elastic as compared to that of arteries. Lumen is wide. Veins carry deoxygenated blood except pulmonary veins that bring oxygenated blood from lungs to the heart. Veins are generally superficial.

Capillaries: They are very narrow blood vessels **(4-10** um) having a single layered wall (endothelium), which form network inside body organs. Movement of blood is very slow (1 mm/sec) so as to provide time for exchange of materials. The wall has very fine pores for exchange of substances between blood and tissue fluid.

Double Circulation

It is a passage of the same blood twice through the heart first on the right side, then on the left side in order to complete one cycle. Double circulation has two components, pulmonary circulation and systemic circulation.

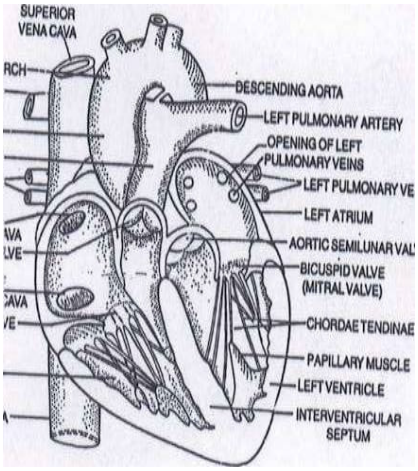
(i) **Pulmonary Circulation:** It is movement of blood from heat to the lungs and back. Deoxygenated blood of the body enters the right auricle, passes into right ventricle which pumps it into pulmonary arch. With the help of two separate pulmonary arteries the blood passes into the lungs. Here the arteries break up into arterioles and then capillaries for oxygenation. Capillaries join to form venules and then veins. Oxygenated blood comes back to left auricle of heart through four pulmonary veins, two from each lung.



(ii) **Systemic Circulation:** It is the circulation of blood between heart and different parts of the body except lungs. Oxygenated blood received by left auricle passes into left ventricle. The left ventricle pumps it into aorta for supply to different body parts including walls of the heart with the help of arteries. Inside the organs the arteries break up into arterioles and then capillaries. Capillaries provide oxygen and nutrients to tissues. They receive carbon dioxide and wastes from the tissues. Capillaries unite to form venules which join to produce veins. Veins take the deoxygenated blood which comes back to the heart but now into the right auricle.

Heart

Structure of the human heart: - The human heart is a cone shaped, muscular organ situated under the breastbone and between the lungs inside the thoracic cavity. It is of the size of human fist and lies slightly towards the left side of the chest cavity. It is divided into four chambers having two atria and two ventricles. The two halves are separated by a thick wall called septum. Each half is composed of two chambers, a relatively thin walled auricle and thick muscular ventricle. Each atrium opens into a ventricle of its own side through an atrio ventricular aperture. The two apertures are guarded by valves, which opens only in the ventricle and prevents the backward flow of the blood. The left atrium and ventricle are separated by a pair of flaps called the Bicuspid or Mitral valve. Similarly the right auricle and ventricle are separated by three flaps called Tricuspid or Mitral valve. The atrium receives the blood from veins and on contraction forces it in to the ventricle, which in turn contracts simultaneously and forces the blood into the arteries. When the ventricles relax, the semi lunar valves of these arteries are closed to prevent backward flow of the blood into the ventricles.



Circulation of blood through heart: - The right atrium receives deoxygenated blood from the body mainly through two vessels or venacavas. From the right atrium blood passes through the tricuspid valve into the right ventricle. When the right ventricle contracts, the blood is forced into the pulmonary artery, which carries it to the lungs for oxygenation. After oxygenation, it is returned back to the heart through the pulmonary vein, which opens into the left atrium. The left atrium passes the blood into the left ventricle through the bicuspid valve. The ventricle on contraction passes this oxygenated blood into the aorta for distribution to all parts of the body.

The heart contracts about 72 times in the similar fashion in one minute and the total volume of the blood pumped out by the heart in every minute varies approximately in between 5 - 6 liters. However, the course of blood circulation in man can be represented as under: -

Oxygenated blood --------► Left atrium -------- ► Left ventricle -------► Aorta-------- ► Arterioles ——► Organs ---------- ► Venous capillaries -------► Venules(Deoxygenated blood) -------- ► Veins ------- ► R.Auricle ------- ► R. Ventricle------ ► Pulmonary artery ------► Lungs (For oxygenation) -------- ► Pulmonary veins ------- ► Left atrium

Arterial Blood Pressure: - It is the pressure exerted by the blood on the wall of the blood vessels in which it is present. It is of two types: -

a) Systolic Blood Pressure (SBP) : - It is the pressure which the blood exerts on the wall of the blood vessels at the end of systolic contraction of ventricles. In a normal resting adult, it is about 120 mm Hg.

b) Diastolic Blood Pressure (DBP): - It is pressure, which the blood exerts on the wall of the arteries when the ventricles are maximally relaxed. In normal resting adult, it is about 80 mm Hg.

Blood

Note: - *(Blood Pressure in a normal person is equal 120/80mm Hg)*

Lymph: - The tissue fluid that bathes the cells is collected in tubes and is then called as lymph. It is filtered the blood plasma through the capillaries. Although partly reabsorbed into the capillaries, most of it flows into a system of fine channels, which repeatedly join together to form a large duct and ultimate the fluid is returned into the blood stream. This additional system of vessels is called as lymphatic system. It runs parallel to the veins and forms another medium of circulation in the human body. The lymph is light yellow in colour and similar in composition to the blood plasma. It is not only found in the lymphatic vessels and bathing the cells of the body, but also in the various cavities of the body, such as the Coelomic cavity, Pleural cavity, Pericardial cavity etc. where it serves as a lubricant.

Functions of lymph: - The chief functions of lymph in the human body are mentioned as under:

1. It serves as a lubricant for the cells and tissues of the body.
2. It serves to return the interstitial fluid into blood
3. It gives the blood macromolecules of plasma proteins.
4. It carries absorbed fats and lipids from small intestines to the blood.

Excretion: - It is a process of removal of the various toxic waste products from the body, produced in the different metabolic processes, undergoing inside the body of an organism,. It eliminates solid, liquid and gaseous waste products produced in the metabolism and thus maintains the relative constancy of the body's internal environment without which life is impossible.

Organs of excretion: - The chief organs of excretion include: -

1. Skin: - It excretes out various dissolved salts along with surplus water from the body. The process takes place through the minute microscopic pores of the skin mainly in the form of sweat and is referred to as perspiration.

Lungs: - These expel out the gaseous wastes like carbon dioxide produced during the cellular respiration in the body through the process referred to as expiration.

3. Kidneys: - These excrete out nitrogenous wastes produced in the body like ammonia, urea and uric acid during various metabolic processes. These are excreted out mainly in the form of urine.

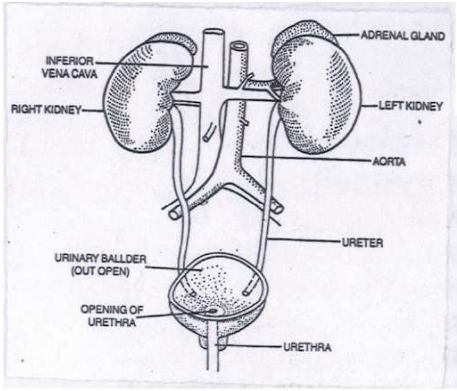
4. Large intestine: - It excretes out the solid wastes like undigested components of the food material produced during the process of digestion. These excreted or defecated out through the anus.

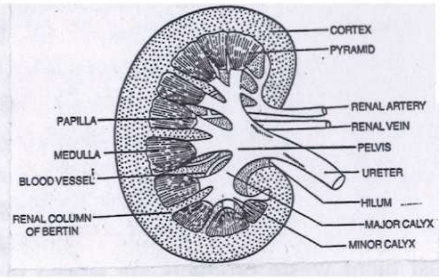
5 Excretory system of man: - The excretory system of man consists mainly of two kidneys, two ureters, a urinary bladder and a urethra as shown under in the diagram.

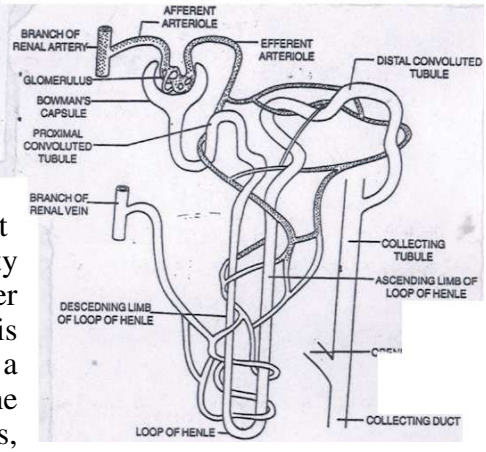
Kidney

Structure of human kidneys: - The human kidneys are reddish brown-paired structure, which lie along the posterior side of the abdominal wall on either side of the vertebral column. Each kidney is bean shaped about 10cm long, 6cm wide and 4cm broad. Each kidney is enclosed in a thin, tough, fibrous, whitish capsule. The outer surface of each kidney is convex while the inner one is concave. The inner side of kidney is composed of two main regions, a dark outer region called cortex and a

lighter inner zone called medulla. The cortex contains uriniferous tubules or nephron, which manufacture the urine; the medulla contains conical projections called renal pyramids containing tubules, which carry urine from nephron to the pelvis of the kidney. From this region, the urine is taken to the urinary bladder through a long tuber called ureters as shown in the diagram.







Structure of Nephron: - The nephron forms the functional unit of the kidneys. Its one end is modified into a cup shaped cavity called Bowman's capsule, which is linked by a small single layer of squamous epithelial cells. The rest of the nephron is differentiated into a coiled proximal convoluted tubule, a U-shaped loop of henle and a distal convoluted tubule. The distal tubule opens into a branching system of collecting tubules, which finally opens into a funnel shaped renal pelvis.

Each nephron maintains a close contact with the blood vessels. It filters and removes the wastes from the blood, which is partially stored in renal pelvis. The urine so formed is then passed out through a long narrow tube called ureters and stored in a sac called urinary bladder, where from it is excreted out of the body through urethra.

Process of Mechanism of excretion: - The entire process of excretion involves three main processes viz.

Glomerular filtration:- When the blood enters into the glomerulus through the afferent arteriole, a part of the water and some dissolved constituent of the blood of low molecular weight like nitrogenous waste, glucose and mineral salts filter out through the capillary walls into the surrounding Bowman's capsule by a process referred to as Glomerular filtration. The filtered fluid or glomerular filtrate resembles the blood plasma in its chemical composition except for the absence of large molecules.

In man, about 180 liters of fluid is filtered from the blood plasma through glomerular capillary walls every 24 hours.

Tabular Reabsorption:- The glomerular filtrate flows on through the convoluted tubes, collecting tubule and then into the pelvis of the kidney and down the ureters into the urinary bladder. As the filtrate flows the proximal convoluted tubule some water and physiologically important salts like glucose, amino acids, sodium chloride and sodium bicarbonate are reabsorbed into the blood through the capillaries around this portion leaving only the wastes to be excreted out.

Active secretion: - As the glomerular filtrate flows through the distal convoluted tubule, the unwanted substances, which could not be filtered out in the glomerular are actively secreted out by the tubular walls into the filtrate from the blood.

As a result of this entire process, homeostasis of the blood is maintained and all the waste products remained in the tubular fluid constitute the urine, which is ready for excretion from the body.

Haemodialysis: - In patients suffering from renal failure or nephritis, artificial measures are adopted for removing the accumulated waste products like urea from the blood. This process is called Haemodialysis and the apparatus used in this process as artificial kidney.

In Haemodialysis, the blood of the patient is taken out from the main artery and cooked to 00C. then an anticoasulant (heparin) is mixed with it and Dumped into the apparatus. Inside the

blood flows through tubes bounded by cellophane membrane, which is permeable to only small molecules like urea, uric acid, creatanin and mineral ions. The dialyzing fluid used in the apparatus a salt solution isotonic to blood plasma, so that the blood flowing through the channels or tubules containing wastes like urea, uric acid, creatanin etc diffuses out in the dialyzing fluid across the cellophane membrane. This process is called dialysis. Finally the blood coming out of artificial kidney is warmed to body temperature and mixed with ant- heparin to restore its normal coagulability and then pumped into the body of the patient through a vein.

Mechanism of Excretion in plants:-

Plants do not have any mechanism to collect, transport and throw out their waste products. They have adopted varied strategies to protect their living cells from waste products,

(i) **Old leaves:** Waste products are stored in older leaves which soon fall off.

(ii) **Old Xylem:** Resins, gums, tannins and other waste products are deposited in the old xylem which soon becomes nonfunctional, e.g., heart wood.

(iii) **Bark:** Bark consists of dead cells which is peeled off periodically. Tannins and other wastes are deposited in the bark. Incidentally, tannins are raw material for dyes and inks.

(iv) **Central Vacuole:** Most plant waste products are stored in central vacuole of their cells. They are unable to influence the working of cytoplasm due to presence of a selectively permeable membrane called tonoplast.

(v) **Root Excretion:** Some waste substances are actually excreted by the plant in the region of their roots.

(vi) **Detoxification:** The toxic oxalic acid is detoxified by formation of calcium oxalate which gets crytallised into needles (raphides), prisms (prismatic crystals), stars (sphaeraphides) and crystal sand. Excess of calcium is also precipitated as calcium carbonate crystals, e.g., cystolith.

(vii) **Salt Glands:** They excrete excess salts obtained from the habitat. Hydathodes also have an excretory function.