Concepts & Notes

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BIOLOGY

Class - X

Life Processes

We observe two types of things around us - living and non-living. All living organisms and non-living matter have one thing in common that they are made up of the same basic elements like carbon, hydrogen, oxygen, nitrogen, etc. Both living and non-living organisms are subjected to same physical laws such as gravitation, radiation, magnetism, etc. Still the living organisms and non-living matter are different from each other on the basis of certain fundamental characteristics.

Living organisms, whether they are unicellular or multicellular, show certain basic characteristics for the maintenance of their life, even when they are sleeping or not doing anything. The processes which together perform this maintenance job and are essential for sustaining life are called life processes.

The various biochemical reactions/processes which take place in the living organisms are called metabolism or metabolic activities. In order to perform these metabolic activities, living organisms continuously require energy. Energy is required even during sleep. When we are asleep, a number of biological processes, like beating of heart, respiration, urine formation, digestion of food, etc. are continuously occurring in the body.

Living beings get energy from the food they eat. In unicellular organisms specific organs for taking in food, gaseous exchange, expelling out of waste and internal transport are not present because the entire surface of the organisms is in contact with the environment and these processes occur by diffusion. However, in complex multicellular organisms all the body cells are not exposed to external environment. Therefore, simple diffusion will not meet the requirements of all the cells. In such organisms specialized organs/organ system carry out various life processes?

Some of the important life processes which are needed for living are:

- Nutrition (manufacturing their own food or intake of food and its digestion).
- Respiration (obtaining and utilizing energy).
- Transport of materials and fluids.
- Excretion (elimination of body wastes).
- Reproduction (producing young ones).
- Movement and locomotion (move by themselves).
- Control and coordination (response to stimulus).
  In this chapter you will study about basic life processes i.e., nutrition, respiration, transportation and excretion.

ILLUSTRATION

1. What criteria do we use to decide whether something is alive?

Ans. We can decide that something is alive on the basis of certain specific characteristics, which are not found in non-living objects. The important characteristic features of living beings are as follows:

(i) All living beings are made up of cell or cells with protoplasm inside it.

(ii) All living beings respire by inhaling oxygen and exhaling carbon dioxide.

(iii) All living beings require food for performing life activities.

(iv) All living beings exhibit growth and development of body organs.

(v) All living beings exhibit certain kind of movement.

(vi) All living beings respond to specific stimuli.

(vii) All living beings increasing their number through reproduction'.

2. What are the raw materials used by an organism?

Ans. The raw materials used by an organism are:

Oxygen: for respiration and production of energy, i.e., ATP.

Food: to be oxidized in order to release energy and for growth and maintenance of body

Minerals and vitamins: for proper maintenance of body.

Carbon dioxide. In case of autotrophs for synthesis of food through photosynthesis.

Water: to take part in all physiological processes.

NUTRITION

Nutrition is defined as a process by which living beings procure food or synthesize it and change it into simple absorbable form by a series of biochemical processes. The chemical substance present in the food are called nutrients. Thus, nutrients can be defined as substances which an organism obtains from its surroundings and use as source of energy and for the biosynthesis of body constituents. Organisms obtain nutrition and nutrients from the food they eat.

Modes of nutrition

There are two basic modes of nutrition: Autotrophic and Heterotrophic.

Autotrophic nutrition

In autotrophic nutrition, organisms manufacture their own food from simple inorganic raw materials. The organisms which show the autotrophic mode of nutrition are called autotrophs.

Depending upon the source of energy used in the preparation of food, autotrophic nutrition is divided into two types-photosynthetic and chemosynthetic.

Photosynthetic nutrition: This mode of nutrition is characteristic of green plants. These plants trap solar energy and manufacture their food in the form of simple sugar from inorganic compounds like CO_2 and H_2O in the presence of chlorophyll. This process is known as photosynthesis. Such organisms are called photoautotrophs.

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

Chemosynthetic nutrition; In this mode of nutrition organisms make use of chemical energy released during oxidation of simple organic compounds to prepare their food. Such N organisms are called chemoautotrophs. For e.g., sulphur bacteria, iron bacteria, Nitrosomonas bacteria, etc.

HETEROTROPHIC NUTRITION

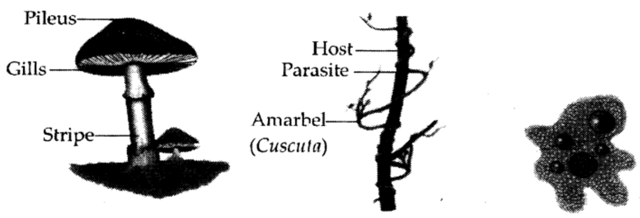
In heterotrophic nutrition, organisms cannot prepare their food by themselves and are directly or indirectly dependent upon autotrophs for their food. Organisms which show this mode of nutrition are called heterotrophs.

Table: Differences between autotrophic and heterotrophic nutrition.

Autotrophic nutrition	Heterotrophic nutrition
1. It occurs in green plants.	It occurs in plants which lack chlorophyll, insectivorous plants, and animals.
2. The raw materials for this type of nutrition are CO_2 and H_2O	The organism which shows heterotrophic nutrition are directly or indirectly dependent on autotrophs.
3. Chlorophyll and sunlight are essential for it.	Chlorophyll and sunlight are not required for it.

Heterotrophic nutrition may be saprophytic, parasitic or holozoic.

Saprophytic organisms release some enzymes to digest the dead organic food and derive nourishment from dead, decaying organic matter. Such organisms are called saprophytes. For e.g., mushroom, mould, yeast.



(a) Mushroom (*Agaricus*) (b) Amarbel (*Cuscuta*) (c) *Amoeba*

Parasitic nutrition: Some organisms live outside or inside the body of other organisms (called host) and derive their nourishment from the host. The mode of nutrition in these organisms is called parasitic nutrition and such artimals are called parasites. For e.g., Plasmodium (malarial parasite), Taenia (tapeworm), Ascaris (roundworm) are parasites in human body. Cuscuta (amarbel) is a plant parasite.

Holozoic nutrition: Holozoic nutrition is defined as the feeding of complex organic matter by ingestion which is subsequently digested and absorbed.

Depending upon the food habits holozoic animals are classified as:

Herbivores: These animals feed on only plants or plant materials. For e.g., cow, buffalo, goat, rabbit, horse, deer, etc.

Carnivores: These animals feed on the flesh of other animals. For e.g., lion, tiger, leopard etc.

Omnivores: These animals feed on both plant as well as animal matter. For e.g., cockroach, sparrow, crow, rat, pig, man, etc.

Holozoic nutrition involves a number of processes like: Ingestion: Taking in complex organic food through mouth opening.

Digestion: Change of complex food into simple diffusible form by the action of enzymes.

Absorption: Passing of simple, soluble nutrients into blood or lymph.

Assimilation: Utilization of absorbed nutrients for various metabolic processes.

Egestion: Expelling out of undigested food.

NURITION IN PLANTS

Green plants make their food by the process of photosynthesis. It is the process of conversion of solar energy into chemical energy. It takes place in the leaves of a plant.

Photosynthesis

Green plants make use of molecules of carbon dioxide from air and water from soil which break up and recombine to form sugar and oxygen by utilizing solar energy in the presence of green pigment called chlorophyll. Thus, during photosynthesis transformation of photonic energy (i.e., light or radiant energy) into chemical energy (locked in light energy bonds of carbohydrates) molecules) takes place. Hence, photosynthesis maybe defined as the synthesis of organic compound (carbohydrates) from carbon dioxide and water by green plants using, radiant energy or sola energy by chlorophyll. Oxygen is evolved as a by-product.

The overall equation of photosynthesis is:

$$6CO_2 + 12H_2O \xrightarrow[\text{Solar energy}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6H_2O + 6O_2 \uparrow$$

The steps involved in photosynthesis are:

- Absorption of solar (light) energy by chlorophyll.
- Conversion of light energy into chemical energy and also splitting of water into oxygen and hydrogen by light energy.
- Reduction of CO_2 to carbohydrates by utilizing chemical energy.
- Within a leaf, photosynthesis occurs particularly in specialized cells, called mesophyll cells. These cells contain chloroplasts.

Significance of photosynthesis

Photosynthesis is important for a number of reasons:

(i) Food: By photosynthesis, green plants synthesize food from simple raw materials like CO_2 and H_2O. Thus it sustains life on earth.

(ii) Oxygen: Oxygen released during the process of photosynthesis is needed by animals and humans. It is also required for respiration of microbes. Oxygen also supports combustion of fuels.

(iii) Fuels: Fossils fuels like coal, oil and natural gas are forms of stored solar energy synthesized by photosynthesis millions of years ago.

ILLUSTRATION

3. What are the differences between autotrophic nutrition and heterotrophic nutrition?

Ans. Differences between autotrophic nutrition and heterotrophic nutrition.

Autotrophic nutrition	Heterotrophic nutrition
1. It occurs in green plants, some bacteria and in some protists.	It occurs in animals and in plants which lack chlorophyll
2. Chlorophyll is necessary for trapping solar energy.	Chlorophyll is absent; as such they do not trap solar energy.
3. Food is self-manufactured using CO_2 and water as raw materials.	Food is obtained directly or indirectly by consuming autotrohps.
4. Digestion of food does not occur.	Digestion is required to convert complex organic substances present in food into simpler and soluble forms.
5. They are placed at the bottom of the food chain as producers.	They are placed above producers in the food chain as consumers.

4. Where do plants get each of the raw materials required for photosynthesis?

Ans. The raw materials required for photosynthesis are water and carbon dioxide. Plants obtain water from soil through their root system and carbon dioxide from atmosphere through stomata. The chlorophyll present in chloroplasts of green plants trap solar energy from sun for photosynthesis.

ACTIVITY CORNER

To prove that carbon dioxide is necessary for the process of photosynthesis.

Materials required: Two healthy potted plants, potassium hydroxide (KOH), 2 bell jars, watch-glass, Vaseline, 2 glass plates, iodine solution, H_2O and alcohol.

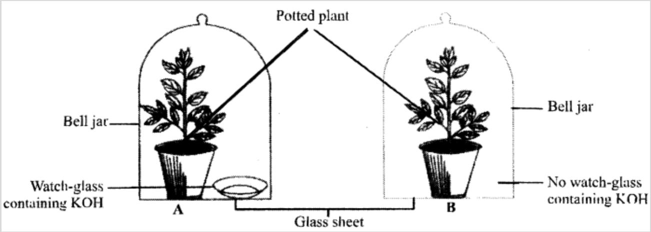


Fig. Apparatus of the activity to show that CO_2 is necessary for the process of photosynthesis.

Procedure: (i) Take two healthy potted plants of same size.

(ii) Destarch them by keeping in a dark room for 3 – 4 days.

(iii) Now place these potted plants on separate glass sheets.

(iv) Place watch glass containing KOH by the side of one of the plants. KOH has the property to absorb carbon dioxide.

(v) Now cover these potted plants with bell jars.

(vi) To make the apparatus air tight use Vaseline to seal the bottom of the jars to glass plates.

(vii) Keep this experimental setup in sunlight for 3 to 4 hours.

(viii) Pluck one leaf from each plant.

(ix) Perform starch test for both the leaves by decolorizing leaf first in water then in alcohol and finally testing with iodine solutions.

Observation: Leaf which was within bell jar with KOH solution gives a negative test whereas other one gives positive test.

Conclusion: The experiment clearly proves the fact that carbon dioxide is absolutely essential for photosynthesis. The part of the leaf which could not show iodine test positive or manufacture starch had all the requirements for photosynthesis except CO_2, which was absorbed by KOH in the bottle.

Chloroplast

Chlorophyll is essential for photosynthesis. It is present in the cell organelles called chloroplasts. Chloroplasts are green-colored plastids.

Each chloroplast is covered by a double-membrane.

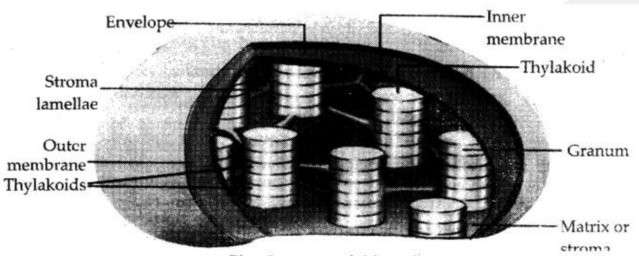


Fig.: Structure of chloroplast.

Inside the membrane, the centre of chloroplast is filled with matrix of stroma. A number of organized flattened membranous sacs called the thylakoids, are present in the stroma.

Thylakoids are arranged in stacks like the piles of coins called grana (singular; granum) or the intergranal thylakoids. In addition, there are flat membranous tubules called the stroma lamellae connecting the thylakoids of the different grana. The stroma of the chloroplast contains enzyme required for the synthesis of carbohydrates and proteins. It also contains small, double-strand circular DNA molecules and ribosomes. Chlorophyll pigments are present in the thylakoids

Events during the process of photosynthesis

The study of photosynthesis demonstrated the existence of two phases, a light phase and a dark phase. The reactions of light phase require light and hence also called photochemical reactions whereas reactions of dark phase require no light (dark) and are purely chemical reactions.

Light phase

It takes place in grana region of chloroplast. The pigment chlorophyll present in the chloroplasts absorbs visible light and after absorption creates such condition that water breaks into protons (H^+) electrons (e^-) and molecular oxygen (O_2). This is called photolysis. The molecular oxygen (O_2). Goes into the atmosphere. The electrons and protons released by the photolysis of water are used up in the production of assimilatory power in the form of NADPH and ATP (reduced nicotinamide adenine dinucleotide phosphate and adenosine triphosphate).

Dark phase

The assimilatory power, generated in the light phase of photosynthesis is used during this phase where carbon dioxide (CO_2) of atmosphere is utilized in the production of carbohydrate. This step is discovered in details by Calvin, Benson and Bassam in the year 1955. It catalyses assimilation of CO_2 to carbohydrates.

The reactions are called carbon reactions. It occurs in stroma or matrix of chloroplasts. The reactions do not required light.

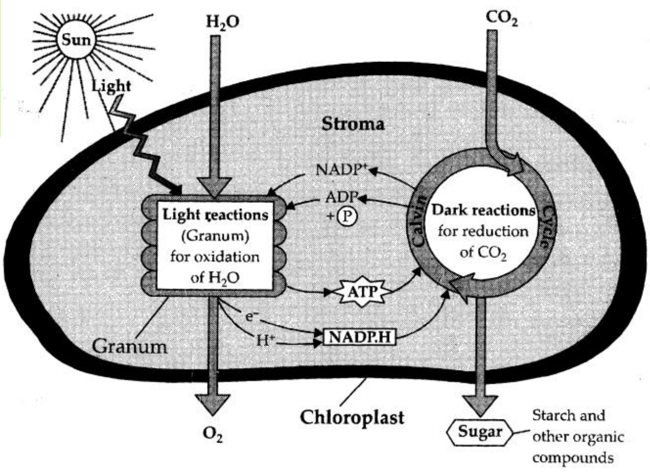


Fig. outline of two phases of photosynthesis

Here CO_2 first of all combines with RuBP **(Ribulose biphosphate).** After a series of reactions, carbohydrate is synthesized and RuBP is regenerated.

Table: Differences between light and dark phase

Light phase	Dark phase
1. It occurs over thylakoids.	It occurs in matrix of chloroplasts.
2. The phase is dependent on light.	The phase does not require light.
3. Temperature has little	It is influenced by

effect over it.	temperature.
4. It produces NADPH and ATP (assimilatory power).	It consumes NADPH and ATP.
5. Oxygen is evolved.	Glucose is the end product

ACTIVITY CORNER

To prove that chlorophyll is essential for photosynthesis.

Apparatus: Plant with variegated leaves, materials for starch test i.e., iodine solution, beaker test tubes.

Procedure: (i) A potted plant with variegated leaf (Coleus, Croton) is kept in darkness for two days to make the leaves starch free

(ii) A plant is then kept in sunlight for a few hours.

(iii) A leaf is removed from a plant and tested with iodine for starch, after decolorizing it first with water and then alcohol.

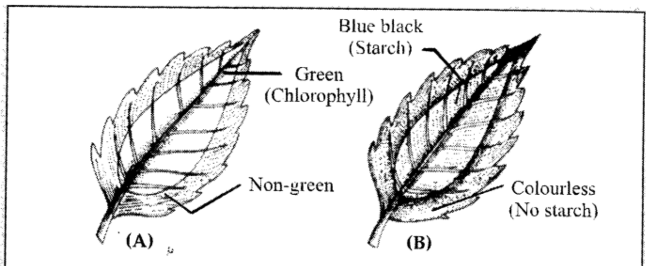


Fig.: Activity to show that chlorophyll is essential for photosynthesis.

Conclusion: It is seen that the portion of the leaf which is devoid of chlorophyll remained colorless (starch-free) whereas the rest of the leaf turned blue-black due to the presence of starch.

ILLUSTRATION

5. Why do we boil the leaf in alcohol when we are testing it for starch?

Ans. The green leaf is boiled in alcohol to extract chlorophyll from it. The leaf then becomes almost colorless or pale. The decolorized leaf is used for iodine test and to observe changes in it.

6. Where is chlorophyll mainly present in a plant?

Ans. Chlorophyll is present in green plastids called chloroplasts. The leaf contains cells which contain chloroplasts. Chloroplasts containing cells are present in more quantity on upper side.

Thus, they are able to get more sunlight

7. Fill in the blanks:

(i) Iodine turns blue-black on reacting with …………………

(ii) CO_2, H_2O, sunlight and …………… Are required for photosynthesis.

(iii) ……………… Is known as the photosynthetic organelle of the cell.

(iv) Site of photosynthesis in a plant is ………..

(v) The two main steps of photosynthesis are called ……………. And ………………… .

Ans. (i) starch, (ii) chlorophyll, (iii) Chloroplast, (iv) leaves, (v) light and dark reactions.

8. Define photosynthesis.

Ans. Photosynthesis can be defined as the synthesis of organic compound (carbohydrate) by green plants from carbon dioxide and water, taken up from the air and soil, respectively, using radiant energy or solar energy by chlorophyll and consequent release of oxygen as a by Product.

9. What are the necessary significant to photosynthesis? How is it significant to mankind?

Ans. The necessary conditions for photosynthesis are the presence of sunlight, chlorophyll, carbon dioxide and water. It is significant to human beings in the following ways:

(i) It helps in maintaining the equilibrium of oxygen in atmosphere.

(ii) It provides us food, directly or indirectly.

(iii) It provides a huge source of energy in the form of coal, wood, petroleum, etc.

Nutrition in Amoeba

Amoeba is a unicellular animal. Amoeba eats tiny (microscopic) plant and animal food which float in water in which4t lives. The mode of nutrition in Amoeba is holozoic. The process of obtaining food by Amoeba is called phagocytosis. Amoeba ingests food by using its pseudopodia.

When a food particle comes near Amoeba, it ingests the food particle by forming temporary finger-like projections called pseudopodia around it. The food is engulfed with a little surrounding water to form a food vacuole inside the Amoeba.

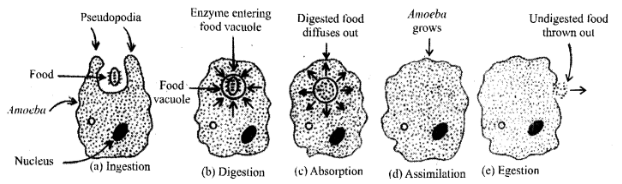


Fig.: Different stages in the nutrition (feeding) of Amoeba.

NUTRITION IN HUMANS

For understanding nutrition in humans, we should understand the digestive system in humans.
Digestive system in human includes alimentary canal and digestive glands.

Alimentary canal

The alimentary canal begins with mouth and ends with anus. It is a muscular coiled tubular structure about nine metres in length. The various organs beginning from mouth in an order are as follows:
Mouth → Oesophagus → Stomach → Small intestine (consisting of duodenum, jejunum and ileum) → Large intestine (consisting of caecum, colon and rectum).
The mouth is bordered by upper and lower lips which helps in taking the food into the buccal (mouth) cavity.
The mouth leads to buccal cavity where three pairs of salivary glands are present, and on the floor of the cavity a tongue bearing taste buds is present. The roof of the mouth is formed by the palate, which separates the air channel from the food channel. The cavity is supported by upper and lower jaws. On the jaws are arranged different kinds of teeth.
Teeth are hard structures present in the mouth cavity and are specially developed for efficient mastication, i.e., mechanically breaking the ingested food into smaller pieces.
In humans, teeth appear in two sets during a lifetime. The first set or milk teeth are 20 in number. These are completely Molars replaced by permanent teeth by about 12 years of age.

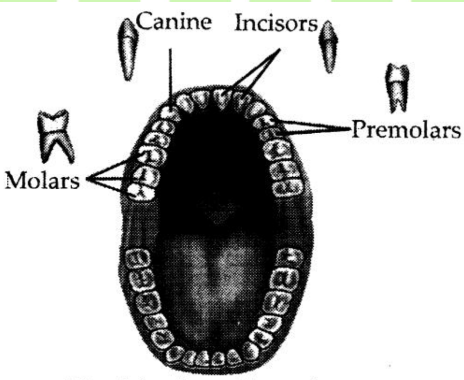


Fig.: Mouth and buccal cavity

Permanent teeth in each jaw are:

- 4 incisors (used for biting)
- 2 canines (used for tearing)
- 4 premolars (used for grinding)
- 6 molars (used for grinding)

Tongue is a muscular, sensory organ, and bears taste buds. It helps in tasting the food, mixing the food with saliva and swallowing the food.
Taste buds are present on the surface on the tongue. Taste buds present near the top of the tongue are meant for knowing the sweet taste, those present laterally taste the sour and salty substances while those present in the posterior part of the tongue are mean for bitter taste.
Buccal cavity opens into the pharynx. It is the common passage for food and air. The food tube continues as oesophagus (food pipe). The air passage continues as larynx and trachea (wind pipe).
The oesophagus is a long and tubular structure which serves to carry the food from pharynx to the stomach. The wall of oesophagus is highly muscular. The oesophagus is not concerned with the digestion of the food. It exhbits peristaltic movement, i.e., contraction and expansion movement of walls, so that the partially digested food is pushed forward in the tract. In fact, this movement occurs throughout the alimentary canal.

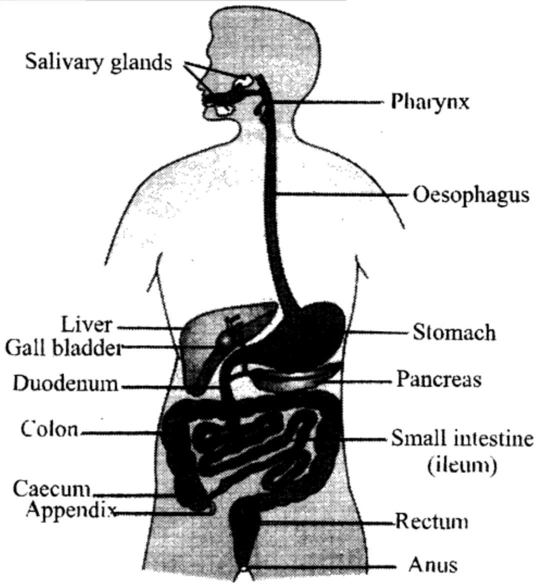


Fig. : Human alimentary canal.

The stomach is a wide C-shaped or J-shaped muscular sac present on the left side of the abdomen. Partially digested food reaches into the stomach from the buccal cavity through pharynx and oesophagus. Its muscular wall contains gastric glands. These glands secrete gastric juices which contain enzymes, mucus and hydrochloric acid (HCl). Food is churned in stomach.
When excess HCl is secreted, it causes acidity. The small intestine is the longest part of the .alimentary canal. It is a narrow tube of about 6 metres which lies coiled in the abdomen. The length of small intestine

varies in different animals depending on the type of food they eat. It is comparatively longer in herbivorous animals which eat grass and shorter in carnivores which eat meat. Longer small intestine of herbivores is helpful in digestion of cellulose. Meat is digested easily, therefore, carnivores have a shorter small intestine. Partially digested and churned food from the stomach enters into the small intestine. The small intestine is the main region for the absorption of digested food. It consists of the following parts:

- **Duodenum** is the initial part of the small intestine. It is 'C' shaped, into which the bile and the pancreatic ducts open with a common bile duct.
- **Jejunum** is the part next to the duodenum. It is a short region of small intestine before ileum.
- **Ileum is the longest part of the small intestine.**

Internally, the wall of the small intestine is provided with long finger-like projections called villi, which increase the surface area and hence, enhance the absorption capacity. At the base of villi are present intestinal glands. These secrete digestive enzymes for digestion of proteins, carbohydrates and fats.

Large intestine is wider than small intestine. It is about 1.5 to 1.8 m long and lies outside the small intestine. It has three parts: caecum, colon and rectum.

The point where the ileum joins the large intestine, a sac-like part called the caecum is present, from which a finger-like structure called vermiform appendix arises. It is a vestigial (functionless) organ in man. The caecum lead into colon that further lead into the rectum. The external opening or rectum is called anus which is kept closed by a ring of muscles called the anal sphincter. It opens only during defaecation (also written as defecation).

Digestive glands

There are three digestive glands associated with the alimentary canal. These are salivary glands, pancreas and liver while gastric and intestinal are other glands present in our body. All these glands play important role in the digestion of food.

(i) Salivary glands: Three pairs of salivary glands; parotid (cheek), sub maxillary or submandibular (lower jaw) and sublingual (below the tongue) are present in the mouth. These glands secrete saliva which performs two functions:

(a) Lubricates food and helps in swallowing.

(b) Saliva contains an enzyme - salivary amylase (previously known as ptyalin) which acts on starch and digests it partially.

(ii) Pancreas: It is a lobed gland situated in between the stomach and duodenum. This gland secretes pancreatic juice which contains three enzymes - lipase, trypsin and amylase which act on fats, proteins and starch respectively. This gland also secretes hormones - insulin and glucagon which regulate glucose metabolism in the body. Pancreas opens into the duodenum through a duct called common bile duct.

(iii) Liver: It is the largest gland of the body. It is dark-brown, and divided into two main lobes- right and left lobes. It is present in the abdominal cavity immediately below the diaphragm. On the undersurface of liver, gall bladder is present. Bile is made in the liver and stored in gall bladder. Bile is released into small intestine when food enters in it. It contains no enzymes but contains bile salts which help in digesting and absorbing fats.

(iv) Gastric glands: Gastric glands are present in the wall of stomach and secrete gastric juice.

(v) Intestinal glands: These lie in the wall of small intestine and secrete intestinal juice (or succus entericus).

Digestion of food

Digestion in mouth

Digestion of food begins in mouth. The food ingested is chewed by teeth and broken into smaller particles so that large surface area is provided for the action of enzymes. This food is mixed with saliva secreted by salivary glands which moistens and lubricates the food and helps in swallowing. Also the enzyme salivary amylase (ptyalin) acts on starch present in the food and breaks it into maltose, a disaccharide. The medium is alkaline or neutral.

The masticated food is now rolled into a ball or bolus by the tongue and passed through the pharynx into oesophagus by swallowing. During swallowing the epiglottis closes and prevents the food from entering the trachea (the wind pipe). The food is passed along the oesophagus by peristalsis.

Digestion in stomach

As the food reaches the stomach, it is mixed with the gastric juice secreted by the gastric glands. The contents of the stomach are churned by the action of muscles of the stomach. The gastric juice contains dilute hydrochloric acid, mucus and two enzymes rennin and pepsin. A small amount of gastric lipase is also present in gastric juice. Rennin coagulates the milk into curd. This action helps in its further digestion by enzymes. Pepsin gets activated in acidic medium

and acts upon the proteins to convert them into peptones (an intermediary product).
HCl present in gastric juice kills the bacteria swallowed along with the food and makes the medium acidic for activation of pepsin.
Gastric lipase partially breaks down lipids. While still in stomach the food is churned by the muscular activity of the stomach to a creamy fluid called chyme. The food remains in stomach for about three hours and is periodically poured through the pyloric into the duodenum in small amounts.

Digestion in duodenum
When the sphincter muscles relax, the chyme enters the duodenum which receives two juices:
(i) bile from the liver; (ii) pancreatic juice from the pancreas. Bile is a yellowish fluid produced in liver and stored in gall bladder. Pancreatic juice contains a number of enzymes which act in alkaline medium. The medium is made alkaline by bicarbonate ions secreted by duodenal wall. The enzymes are:
(a) Trypsin: converts remaining proteins into peptones and the peptones into peptides and amino acids,
(b) Amylase: converts the undigested starch into maltose (continues the process that begun in mouth), and
(c) Lipase: converts fats into fatty acids and glycerol.

Digestion in ileum
From the duodenum the food is slowly moved down to ileum where more digestive changes come into action. The intestinal juice called succus entericus secreted by intestinal glands contains the following enzymes which act in alkaline medium:
(i) Trypsin: converts peptones into amino acids,
(ii) Maltase: converts maltose (complex sugar) into glucose (simple sugar),
(iii) Lactase: converts lactose into glucose and galactose,
(iv) Sucrase: converts sucrose into glucose and fructose, and
(v) Lipase: converts fats into fatty acids and glycerol.
Thus, the digestion started in mouth is completed in the small intestine. The digested food consists of soluble products - monosaccharides, amino acids, fatty acids and glycerol. These can be absorbed into the blood stream. The digestion and absorption of the food takes place throughout the length of the small intestine as the contents gradually move down by peristalsis.

ACTIVITY CORNER

To demonstrate the action of saliva on starch.
Materials required: Two test tubes, 1% starch solution, dilute iodine solution.
Procedure: Take two test tubes – A and B. Add 1 ml of 1% starch solution in each test tube. Now add 1 ml saliva to test tube A. Leave both are tubes undisturbed for about 20-30 minutes.
Now add a few drops of dilute iodine solution in both the test tubes and observe.
Observation and conclusion: The blue color appears in test tube B showing the presence of starch. The blue color does not appear in test tube A. This indicates that salivary amylase present in saliva has broken down starch into soluble sugar.

Absorption of food

Absorption is the process by which the products of digestion are taken into the blood stream. Most of the absorption of food material takes place in the ileum. The absorption surface is greatly increased by the presence of millions of finger-like projections called villi. Each villus is covered by epithelium and contains blood vessels and lymph vessels. The villi are bathed in the digested food products contained in the lumen of intestine and the food diffuses through the epithelium into the blood vessels. Glucose, amino acids, minerals and vitamins are absorbed in the blood vessels of the villi; the fatty acids and glycerol are absorbed by lacteals, which are carried to lymph vessels to the point where the lymph vessels empty into the blood stream.
No enzymes are secreted in large intestine. This part is concerned with the absorption of water. The undigested semi-solid food which remains in small intestine is passed into large intestine. In the large intestine water is absorbed from it. The undigested waste called faeces is stored in the rectum from where it is egested through the anus. The process of elimination of undigested food is called defaecation. The roughage in the diet helps in promoting the movement of bowels.

Assimilation of food

The food after digestion and absorption is assimilated into body substances and protoplasm of the cells. This takes place in following ways:
- The final products of fat digestion (fatty acids and glycerol) are absorbed in the blood stream

through the lacteals. In the body they are again converted into fats and excess fats are stored in adipose tissue. This stored fat can be utilized by the body in times of need.

- The simple sugars absorbed through the intestinal villi are used for generating energy for various life activities. The excess sugars are converted into a complex polysaccharide, glycogen, in the liver. It can be reutilized during stress conditions.
- The amino acids are utilized to synthesize different proteins required by the body.

Egestion

The undigested or unassimilated portions of the ingested food material is thrown out from the body through the rectum and anal aperture as faecal matter. This is known as egestion.

ILLUSTRATION

10. State two function of chewing of food.

Ans. Chewing helps in breaking down of food into small tiny particles and increases the surface area available for enzymatic action.

11. Why it is said that animals derive energy ultimately from the sun?

Ans. Animals cannot manufacture their own food as they do not have chlorophyll. They have to depend upon autotrophs for their food supply, as autotrophs have the potential to manufacture food. Animals take complex organic food prepared by autotrophs and then break it down into simpler forms. Since autotrophs prepare their food by utilizing sunlight directly, it is correct to say that all animals get their energy ultimately from the sun

12. Why is digestion in Amoeba said to be intracellular?

Ans. Intracellular means within a cell. Amoeba is a single-called animal. All the life activities have to be performed within a single cell. Amoeba engulfs its food from the surrounding environment. Digestion, absorption, and assimilation occur inside the cell, hence it is said to exhibit intracellular mode of digestion.

13. Carbohydrates are more suitable for the production of energy in the body than proteins and fats. Give reason.

Ans. Carbohydrate molecules contain relatively more oxygen than protein and fat, and consequently, require less molecular oxygen for their oxidation. For each litre of oxygen consumed, carbohydrates yield far more energy than proteins or fats. Carbohydrates remain stored in the tissues as glycogen for use in the production of energy when necessary.

14. When a piece of bread is chewed slowly, it tastes sweeter after some time. Give reason.

Ans. Human saliva contains a starch hydrolyzing enzyme know as salivary amylase or ptyalin. Ptyalin causes hydrolysis of starch into disaccharides, maltose and isomalstose and a small amount of dextrin, often called as 'limit dextrins'.

When a piece of bread is chewed slowly, ptyalin gets enough time to act and sweet tasting maltose is produced from the starch.

15. What is the role of acid in our stomach?

Ans. Along with enzymes, gastric secretion includes hydrochloric acid, which plays an important role in the process of digestion. These are:

(i) HCl creates an acidic medium inside stomach which essential for the activation and action of the gastric enzyme pepsin.

(ii) HCl kills the harmful bacteria present in the food.

16. What is the function of digestive enzymes?

Ans. The major constituents of the diet are relatively complex, such as carbohydrate, protein fat etc. which cannot be absorbed unless they are broken down into simple compounds. The function of digestive enzymes is to help in breaking down of complex food materials into simpler compounds which can be readily used by animals through absorption and assimilation. As such, digestive enzymes help in converting proteins into amino acids, fats into fatty acids and glycerols and polysaccharides into monosaccharides.

17. How is the small intestine designed to absorb digested food?

Ans. Human intestine is several matres long. The mucosa of small intestine is folded and projected in the form of finger-like structures, the villi, which increases the absorptive surface manifolds. Moreover, villi are highly vascular containing blood capillaries and lymph capillaries. Furthermore, the epithelial lining of small intestine is very thin which facilities rapid diffusion of substances.

CONCEPT MAP

Nutrition

Two types

Autotrophic

The organisms prepare (or synthesize) their own organic food utilising only the inorganic raw materials present in the surroundings.

Heterotrophic

The organisms derive energy from the intake and digestion of the organic substances prepared by autotrophs and other organic sources.

Nutrition

In plants

Green plants make their food by the processes of photosynthesis. It is the process in which green plants make use of CO_2 and water to form sugar and O_2 by utilizing solar energy in the presence of chlorophyll. Photosynthesis has two phases: Light phase and Dark phase. It takes place in the leaves of a plant.

In unicellular organisms

Amoeba is a unicellular organism. *Amoeba* eats tiny (microscopic) plants and animals food which float in water in which it lives. The mode of nutrition in *Amoeba* is holozoic. The process of obtaining food by *Amoeba* is called phagocytosis.

In humans

The food undergoes digestion, absorption, assimilation & egestion.

Alimentary canal

Mouth → Oesophagus → Stomach → Small intestine (consisting of duodenum, jejunum and ileum) →Large intestine (consisting of caecum, colon and rectum).

Digestive glands

Salivary glands, gastric glands, pancreas, liver and intestinal glands.

RESPIRATION

Earlier, the phenomenon by which O_2 is absorbed and CO_2 is liberated from living organisms has been defined as respiration. However, the given definition is infact a kind of gaseous exchange.

Most living things need oxygen to obtain energy from food. This oxygen reacts with the food molecules (like glucose) present in body cells and bums them slowly to release energy. The process of releasing energy form food is called respiration.

The assimilated food molecules hold energy in their chemical bonds. Their bond energy is released by oxidation in the cells. The process of oxidation is carried out with the help of oxygen. Carbon dioxide and water are produced as by-products. Energy is released in this process. This energy is trapped by forming bonds between ADP (Adenosine diphosphate) and inorganic phosphate (Pi) to synthesize ATP (Adenosine triphosphate) molecules. These bonds are later broken by enzymatic hydrolysis and the energy so set free is used by the cells in their activities. For the nonstop release of energy, the cells need uninterrupted supply of oxygen and constant removal of CO_2.

Therefore, respiration is a biochemical process that generally involves (i) intake of molecular oxygen from the environment, (ii) stepwise oxidation of food with incoming oxygen, (iii) elimination of carbon dioxide produced during oxidation and (iv) release of energy due to oxidation of food.

Reaction involved in respiration is:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy (stored as ATP)}$$

TYPES OF RESPIRATION

Respiration can, however, also take place in the absence of oxygen (of air), though very rare. This means that oxidation of food to obtain energy can occur in the presence of oxygen as well as in the absence of oxygen. Based on this, we have two types respiration: aerobic respiration and anaerobic respiration.

Aerobic respiration

When oxygen is used for respiration it is called aerobic respiration. During aerobic respiration, glucose is completely broken down into CO_2 and H_2O by the process of oxidation and a large amount of energy (38 ATP) is produced.
Aerobic respiration includes glycolysis which is common to both aerobic and anaerobic respiration. The pyruvic acid (pyruvate) molecules formed during glycolysis are carried into the mitochondria where they completely break down to CO_2 and H_2O with the evolution of a large amount of energy.

$$\underset{(1\text{ molecule})}{\text{Glucose}} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{(2\text{ molecules})}{\text{Pyruvate}} \xrightarrow[\text{(in mitochondria)}]{\text{Oxygen}} 6CO_2 + 6H_2O + \underset{(38\text{ ATP})}{\text{Energy}}$$

Anaerobic respiration

When food is oxidized without using molecular oxygen, the respiration is called anaerobic respiration. In this type of respiration incomplete oxidation of food takes place, and in comparison to aerobic respiration, much less amount of energy is produced. It also includes lysis which takes place in the cytoplasm. During this process one molecule of glucose is degraded into two molecules of pyruvic acid (pyruvate) and little energy (2 ATP). The pyruvic acid is further converted into ethyl alcohol (ethanol) or lactic acid.

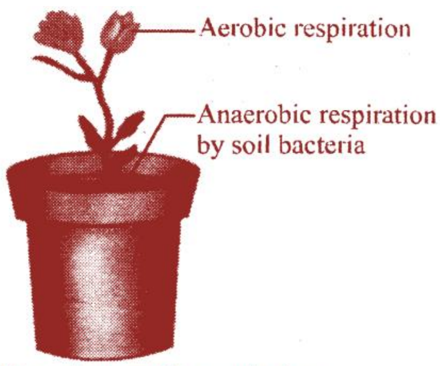


Fig.: Aerobic and anaerobic respiration.

In microorganisms, the term fermentation is more commonly used in place of anaerobic respiration. Fermentation is defined as the anaerobic breakdown of carbohydrates and other organic compounds into alcohol, organic acids, gases, etc. For example, yeast and certain bacteria utilize substances present outside the cells as respiratory substrate, oxidize it to ethanol and carbon dioxide without utilizing O_2.

$$\text{Glucose} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{(2\text{ molecules})}{\text{Pyruvate}} \xrightarrow[\text{(yeast)}]{\text{No } O_2 \text{ required}} \text{Ethanol} + CO_2 + \underset{(2\text{ ATP})}{\text{Energy}}$$

In certain bacteria and parasitic worms (Ascaris, tapeworm, etc) glucose is metabolized to lactic acid without the use of O_2 and without the formation of CO_2. In human beings, anaerobic respiration occurs in certain tissues such as skeletal muscles. These mucles do not get sufficient oxygen and anaerobically metabolize glucose to lactic acid during vigorous exercise.

$$\underset{(1\text{ moleucle})}{\text{Glucose}} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \underset{(2\text{ moleucules})}{\text{Pyruvate}} \xrightarrow[\text{(in cytoplasm)}]{\text{No } O_2 \text{ required}} \text{Lactic acid} + \text{Energy}$$

Respiration and breathing

Respiration involves external respiration and internal respiration. External respiration refers to inhalation of O_2 and exhalation of CO_2 produced during oxidation of food. Internal or cellular respiration involves release of energy in the form of ATP (energy currency) by oxidation of food.
Breathing is a physical process of inhalation of O_2 and exhalation of CO_2. It is simply a process of gaseous exchange. It does not include oxidation of food and release of energy.

Table: Differences between breathing and respiration

Breathing	Respiration
1. It is a physical process. It involves inhalation of fresh air and exhalation of foul air.	It is a biochemical process. It involves exchange of respiratory gases and also oxidatiaon of food.
2. It is an extracellular process.	It is both an extracellular as well as intracellular process.
3. It does not involve enzyme action.	It involves a number of enzymes required for oxidation of food.
4. It does not release energy, rather it consumes energy.	It releases energy.
5. It is confined to certain organs only.	It occurs in all the cells of the body.

RESPIRATION IN PLANTS

Plants have a branching shape, so they have quite a large surface area in comparison to their volume. Therefore, diffusion alone can supply all the cells of the plants with as much oxygen as they need for respiration. All the parts like roots, stems, branches, leaves, etc. respire separately.
Oxygen is obtained from the atmosphere which diffuses in through:

- **Stomata** in leaves
- **Lenticels** in stems
- **General surface of the roots.**

Respiration in roots

Air is present in-between the particles of soil. The roots of a plant take the oxygen required for respiration from the air present in-between the soil particles by the process of diffusion. The root hair are in contact with the air in the soil. Oxygen diffuses into root hairs and reaches all the other cells of the root for respiration. Carbon dioxide gas produced in the cells of the root during respiration moves out through the same root hairs by the process of diffusion.

It has been found that the land plants dies if their roots remain waterlogged for considerable time. This is because too much water expels all the air from in-between soil particles. Due to this, oxygen is not available to the roots for aerobic respiration. Under these conditions, the roots will respire anaerobically, producing alcohol. This may kill the plant.

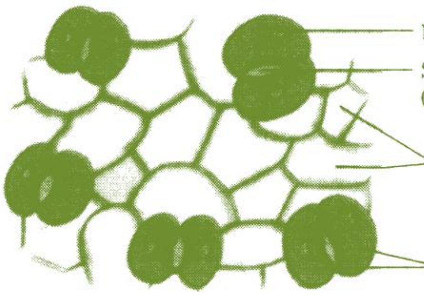
Respiration in stems

In order to understand the respiration in stems of plants we should remember that the soft stems of small, herbaceous plant have stomata in them whereas the hard and woody stems of large plants and trees have lenticels in them. The stems of herbaceous plants (or herbs) have stomata, where the exchange of respiratory gases takes place. The hard and woody stems of big plants or trees do not have stomata. In woody stems, the bark (outer covering of stem) has lenticels for gaseous exchange.

Respiration in leaves

The exchange of respiratory gases in the leaves takes place by the process of diffusion through stomata. Respiration in leaves occurs during the day time as well as at night. Whereas, photosynthesis occurs only during the day time.

Respiration takes place both in the presence and in the absence of sunlight. In the presence of sunlight or during daytime the stomata are open in leaves and in other green tissues (tissues containing chlorophyll) and so, the process of photosynthesis is also in progress. The CO_2 thereby evolved in respiration is reutilized in photosynthesis and the oxygen produced during photosynthesis is used for respiration.



During day time, rate of photosynthesis is much faster than the rate of respiration, there is a net movement of CO_2 from environment to the plant tissue through stomata and O_2 is diffused out from cells to outer environment through stomata.

During night time, the conditions are just reversed, photosynthesis stops and only the process of respiration takes places and as a result O_2 diffuses into plants and CO_2 diffuses out.

Each stomata has an opening guarded by two kidney-shaped guard cells. The inner wall of each guard cell is thick and less elastic while the outer wall is thin and more elastic. If water flows from surrounding cells to guard cells, the turgor pressure in them increases and they expand, resulting in the opening of stomatal aperture. If guard cells lose water, i.e., water moves from guard cells to surrounding cells their turgor pressure decreases, resulting in the closing of stomatal aperture. The gases O_2 and CO_2 after entering through stomata, enter into the sub-stomata space from where they diffuse through the intercellular spaces between the mesophyll cells in the leaf. According to the requirement of plants, gases O_2 and CO_2 enter the cells and diffuse out through the sub-stomatal spaces and guard cells into atmosphere.

RESPIRATION IN ANIMALS

There is a constant exchange of gases between an organism and its environment. The surface of an organism where the gaseous exchange takes place is called respiratory surface. This surface is specially adapted for the exchange of gases.

For an efficient gas exchange, respiratory surface must have the following characteristics:

- The respiratory surface must have a large surface area.
- It should be extremely thin and moist for efficient diffusion.
- It should be richly supplied with blood capillaries.
- Respiratory surface must be permeable to respiratory gases.
- There should be a provision for carrying oxygen to respiratory surface and carrying away CO_2 from the respiratory surface.

Organs of respiration in animals

In lower animals like Amoeba, Paramecium, Euglena, sponges. Hydra, Spirogyra, etc. no specific respiratory organs are present. In these animals exchange of gases takes place from body surface. In earthworm respiration is cutaneous, i.e., exchange of gases occurs through skin. Frog respires through skin as well as through lungs. Thus, it shows both cutaneous as well as pulmonary respiration. In insects like grasshopper, housefly, cockroach, etc respiratory organs are air tubes or trachea. In aquatic animals, like fish, prawn, tadpole, etc., respiratory organs are gills. Fish have gills enclosed inside the gill chambers, one on either side of the body just behind the head.

ACTIVITY CORNER

To study the process of breathing is fishes.

Observe carefully a fish in an aquarium. Note down the presence of gills on both the sides of its head behind the eyes. The gills are not visible from outside because they are covered by gill covers operculum. Observe that the timings of the opening and closing of the mouth and gills slits are coordinates. The fish breathes by taking in water through its mouth and then passing it out though gill slits

Therefore, opening of mouth and movement of gill-slits are coordinates. In fact, the oxygen dissolved in water is absorbed by blood when the latter passes over the gills.

Note down the number of times the fish opens and closes its mouth in a minute and compare it with the number of times you breathe in a minute.

RESPIRATORY SYSTEM IN HUMAN

Respiratory system in human beings consists of nostrils and nasal cavity,-pharynx, trachea and bronchi, lungs, bronchioles and alveoli.

Nostrils and nasal cavity

Nostrils are the nasal openings through which air is drawn into nasal cavity. The nasal cavity is separated from oral cavity by a bony plate. Nasal cavity has central septum which divides it into paired nasal passages. The nasal passages are lined by ciliated epithelium and mucus secreting cells. Both mucus and cilia check the entry of dust particles and microbes.

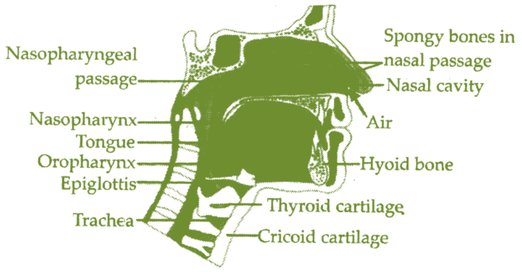


Fig.: The air passage in the nose and throat.

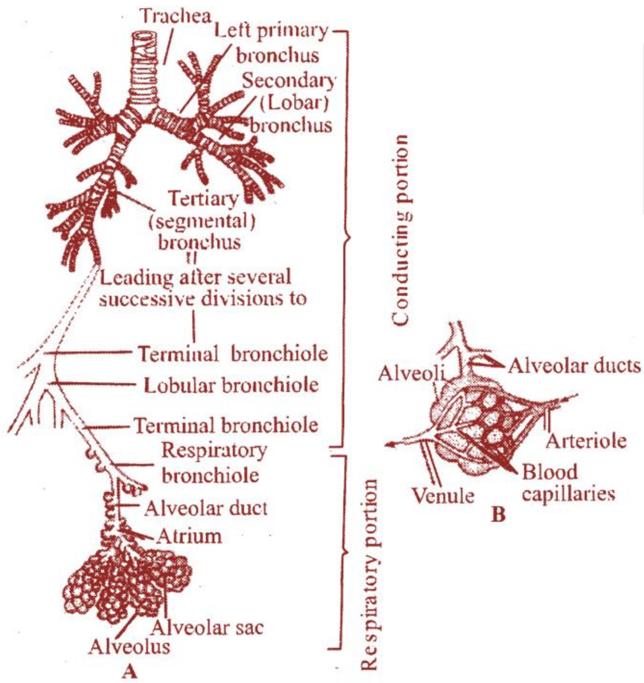
In nasal cavity air is warmed and moistened. Nasal cavity ends in internal nostrils through which air enters into pharynx.

Pharynx

It is a common passage for air and food. It leads into trachea (wind pipe) and oesophagus (food pipe). Oesophagus lies dorsal to trachea. While swallowing the food, glottis (slit-like aperture at the anterior end of trachea) gets covered by a small cartilaginous flap of skin called epiglottis. This epiglottis prevents food or water from entering into the respiratory tract.

Trachea and bronchi

Trachea is about 11 cm in length and 2.5 cm in diameter. Its wall is provided with incomplete (C-shaped) cartilaginous rings, which prevent the trachea from collapsing even if there is not much air in it. Trachea is lined internally by ciliated epithelium and mucus secreting cells. The mucus and cilia both prevent the entry of dust particles and microbes. Trachea runs down the neck and extends into thoracic cavity. On entering the thoracic cavity, trachea divides into bronchi (singular: bronchus). On entering the lungs the right bronchus divides into three bronchi which enter into three lobes of right lung, and left bronchus divides into two bronchi, one branch entering into each lobe of left lung.



Bronchioles and alveoli

Within the lung, each bronchus divides and redivides to form finer branches called bronchioles. Each bronchus with all its branches is called bronchial tree. After repeated divisions each bronchiole ends into a cluster of tiny air chambers called air sacs or alveoli (singular: alveolus). Alveoli are called functional units of lungs as they are the actual sites of respiratory exchange. There are about 750 million of alveoli present in lungs which have a total surface area of about 100 m^2. Alveoli are covered with network of capillaries.

Lungs

The lungs are a pair of spongy, highly elastic and bag-like organs. They are roughly cone shaped and situated in the thoracic cavity. The lower surface of the lungs rests on a diaphragm which forms the floor of thoracic cavity.

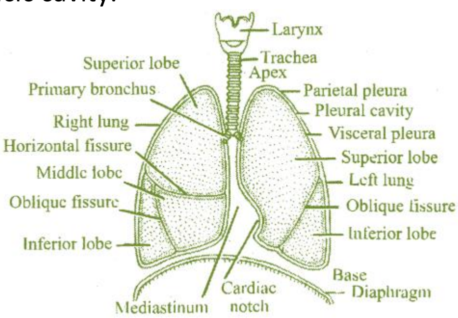


Fig.: Larynx, trachea, primary bronchi and lungs.

The lungs are enclosed by a double-layered membrane called pleura. The pleural membranes are separated by a thin space filled with pleural fluid which lubricates the membrane to avoid friction. Lungs play very important role in the mechanism of breathing.

Mechanism of breathing

Breathing is a mechanical. It involves two steps:

- Inhalation, and
- Exhalation

Inhalation

During inhalation, the diaphragm and the muscles attached to the ribs contract, and the thoracic cavity expands. This makes the thorax move upwards and outwards thereby increasing the volume inside the thoracic cavity. This causes a decrease in the air pressure inside. The diaphragm and a specialized set of muscles- external and internal intercostals between the ribs, help in generation of such pressure gradient both during inhalation and exhalation. As a result, the air from outside rushes into the lungs through the nostrils, trachea and bronchi.

Through the thin walls of the alveoli oxygen diffuses into the blood. Blood then supplies this oxygen to the tissues. This oxygen is then used in the cells for cellular respiration.

Exhalation

As a result of cellular respiration of nutrients in cells, carbon dioxide is produced. This carbon dioxide is absorbed by the blood from the tissues and carried to the alveoli of lungs. At this stage, the thoracic cavity returns to its normal size due to the relaxing of the diaphragm and the rib-muscles, and carbon dioxide is pushed out of the body through trachea and nostrils.

Breathing occurs involuntarily. The rate of breathing however, is controlled by the respiratory centre of the brain. An average rate of breathing in a normal adult man is 15 to 18 times per minute.

Table: Differences between inhalation and exhalation

Inhalation (Inspiration)	Exhalation (Expiration)
1. Intercostal muscles of the ribs contract pulling the ribs and sternum upwards and outwards.	Intercostal muscles of the ribs relax allowing the ribs and the sternum to return to their original.
2. The radial muscles of diaphragm contract, and diaphragm is pulled down and flattened.	The radial muscles of diaphragm relax and diaphragm is pushed back to its original dome-like position.
3. Volume inside the thorax increases.	Volume inside the thorax decreases.
4. Intrathoracic pressure of the lungs decreases and outside air rich in oxygen rushes in through the nostrils.	Intrathoracic pressure of the lungs increases and the inside air rich in CO_2 and water-vapour is forced out through the nostrils.

Activity corner

To demonstrate that we breathe out carbon dioxide.

Materials required: Two test tubes, freshly prepared lime water, glass tube, syringe.

Procedure: Take two test tubes A and B. Pour some freshly prepared lime water in each tube. Now blow air in tube A through the lime water with the help of a glass tube and observe. Pass air through lime water in tube B with the help of a syringe and observe.

Observation and conclusion: The lime water in tube A turns milky showing that we exhale carbon dioxide. On the other hand, the lime water in tube B takes a long time to turn milky. The lime water is a solution of calcium hydroxide. It combines with CO_2 to form a white precipitate of calcium carbonate. This also shows that expired air contains more CO_2 concentration than the atmospheric air (0.04%)

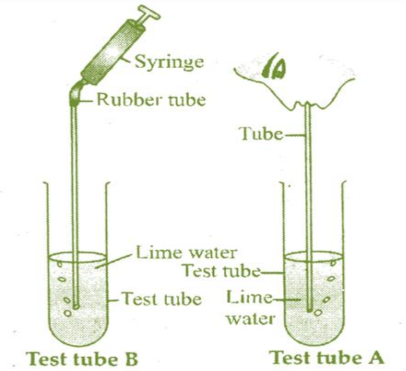


Fig.: Experimental set up to demonstrate that we breathe out carbon dioxide.

ILLUSTRATION

18. Why is diffusion insufficient to meet the oxygen requirements of multicellular organisms like human?

Ans. Unlike unicellular organisms, in higher multicellular forms including man every cell of the body is not in direct constant with the external environment. Only the surface layer cells of skin are exposed to the surrounding environment.

The rest of the body cells of internal organs are not direct contact with environmental. So, exchange of gases by diffusion is not possible in these cells. Thus, multicellular organisms require certain specialized organs for breathing, exchange of gases and transport of gases to meet the oxygen requirement.

19. What are the different ways in which glucose in oxidized to provide energy to various organisms?

Ans. The first step in energy production is the oxidation of glucose, a 6-carbon molecule, into a 3-carbon molecule called pyruvate, by a process called glycolysis. It occurs in the cytoplasm.

The fate of pyruvate depends upon the presence or absence of oxygen. Pyruvate may be converted into ethanol and carbon dioxide in the absence of oxygen. This process takes place in yeast during fermentation. It is called anaerobic respiration. During aerobic respiration, i.e., in presence of oxygen, pyruvate breaks up into carbon dioxide and water using oxygen. The process takes place in mitochondria.

20. How are oxygen and carbon dioxide transported in human beings?

Ans. In this exchange, the blood takes up oxygen from the alveolar air and releases CO_2 to the alveolar air. Such an exchange occurs because the concentration of O_2 is more in alveolar air. We know that O_2 moves from higher concentration to lower concentration due to the process of diffusion. The blood has more concentration of CO_2 as compared to alveolar air. Thus, the CO_2 moves from blood to alveolar air due to simple diffusion. This exchange of gases is called external respiration and results in the oxygenation of blood. The oxygenated blood then returns from the lung by pulmonary veins to the left side of the heart. The heart supplies the oxygenated blood to the body tissues. In times, the exchange of gases occurs between the oxygenated blood and the tissue cells. The concentration of O_2 is more in the blood and less in the tissue cells. So, the O_2 moves from blood to the tissues and less in the blood. So, the CO_2 moves from tissues to the blood. This process is called internal respiration. The blood now becomes deoxygenated.

21. How re lungs designed in human beings to maximize the area for exchange of gases?

Ans. Human lungs have a highly branched network of respiratory tubes. A primary branches divides into secondary bronchus which in turn forms tertiary bronchus. Tertiary bronchus divides repeatedly into bronchioles which finally terminates into alveoli. Alveoli are small, rounded polyhedral pouches which are extremely thin-walled and possess a network of capillaries. Exchange of gases takes place in alveoli and hence an alveolus is called a miniature lung. The alveoli provide a vast surface area when exchange of gases can takes place. Oxygen diffuses from alveoli into pulmonary blood capillaries and CO_2 diffuses out from capillaries into alveoli. It is estimated that the total surface area of alveoli of human lungs is about 100 m^2.

22. What advantage does a terrestrial organisms have over an aquatic organisms with regard to obtaining oxygen for respiration?

Ans. Terrestrial organisms consume atmospheric oxygen, while aquatic organisms thrive on the dissolved oxygen present in water air contain about 21% of oxygen while water has less than 1% oxygen in dissolved state. Oxygen diffuses though water much slower as compared to air. A terrestrial organisms has the advantage of utilizing greater amount of oxygen at a faster rate with lesser effort whereas, aquatic organisms have to exert more effort to obtain the same amount of oxygen.

CONCEPT MAP

Respiration

Two types

Aerobic

When oxygen is used for respiration it is called aerobic respiration.

Anaerobic

When food is oxidised without using molecular oxygen the respiration is called anaerobic respiration.

Respiration

In plants

Respiration takes place both in the presence and in the absence of sunlight. Diffusion of gases occurs through stomata of leaves, lenticels in stems and general surface of the roots.

In animals

There is a constant exchange of gases between an organism and its environment. The surface of an organism where the gaseous exchange takes place is called respiratory surface. This surface is specially adapted for the exchange of gases.

In humans

Mechanism of breathing

Exchange of gases in tissues

Blood takes up O_2 from alveolar air and releases CO_2 into alveolar air.

Inhalation

Air moves in with the contraction of diaphragm and muscles of ribs.

Exhalation

Air moves out with the relaxation of diaphragm and muscles of ribs.

Air moves through

Nostril and nasal cavity

Nostrils are the nasal openings through which air is drawn into nasal cavity. The nasal cavity is separated from oral cavity by a bony plate.

Pharynx

It is is a common passage for air and food.

Trachea and bronchi

Trachea is about 11 cm in length and 2.5 cm in diameter. I wall is provided with incomplete (C-shaped) cartilageno rings, which prevent the trachea from collapsing even if the is not much air in it. It divides into right and left branchi.

Bronchioles and alveoli

Within the lung, each bronchus divides and redivides t form finer branches called bronchioles. After repeate divisions each bronchiole ends into a cluster of tiny a chambers called air sacs or alveoli.

Lungs

A pair of spongy organs situated in thoracic cavity.

TRANSPORTATION

All living organisms are made up of cell/cells. In order to survive and maintain themselves, all cells require oxygen and nutrients. As they perform various metabolic activities, waste products like carbon dioxide, ammonia, urea, etc. are formed in the cells. The harmful substances must be removed from the body to avoid their accumulation to harmful level. Thus, the oxygen and nutrients are to be transported to all the cells/tissues as well as body wastes is also to be transported to the excretory organs. In complex multicellular organisms special organs are needed to pick up oxygen, food, water, etc. and carry them to required places. The transport of substances like oxygen, food, water, enzymes, hormones, etc. inside the body of an organism is called internal transport and the organs which carry out this transport within the body together constitute the internal transport system.

TRANSPORT SYSTEM IN PLANTS

Plants absorb water and mineral salts from the soil by their root system. Unicellular root hairs present in the roots facilitate absorption of water and minerals. The absorbed water and minerals have to be transported from roots to all the parts of the plant. Similarly, the food which is prepared mainly in the leaves by the process of photosynthesis has to be transported to various parts of the plant.

These functions of internal transport in plants are carried out by specialized connecting tissues - xylem and phloem. The water and minerals absorbed by the roots are transported through xylem tissue, while food prepared by the leaves is transported through phloem. The transport of food prepared in the leaves by the process of photosynthesis to various parts (roots, stem, branches, etc.) of the plant is called translocation.

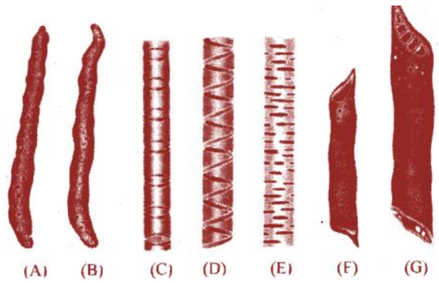
The upward movement of water and mineral salts from roots to the aerial parts (leaves, branches, flowers, etc.) of the plant against the gravitational force is called ascent of sap.

Transport of water and minerals (ascent of sap)

Ascent of sap is carried out by xylem tissue.

Xylem tissue consists of four components xylem vessles, xylem tracheids, xylem fibres and xylem parenchyma.

In flowering plants xylem vessels and tracheid's conduct water and minerals and in non-flowering plants tracheid's are the only conducting cells. The xylem vessels which are elongated, non-living, lignified and placed end to end without any cross walls, form the pipeline for conducting water and minerals from roots to the leaves. Tracheids are long, thin, spindle-shaped cells with pits in their thick walls. Water flows from one tracheid to another through pits.



Minerals and water needed by the plants are absorbed by roots. The root hairs absorb water from the soil by the process of osmosis and take in minerals by the process of diffusion. Thus, a difference in concentration of ions is created between the roots and the soil which enables the water to enter into roots to compensate the difference in concentration. This water along with dissolved minerals from the root hairs passes into xylem vessels through cells of cortex, endodermis and pericycle and then ascent of sap takes place from xylem of roots into the xylem of stem and finally leaf veins through vessels and tracheids.

About 1 to 2% of the water absorbed by the plants is used in photosynthesis and other metabolic activities.

A lot of water evaporates through stomata present in the surface of leaf. This process is called transpiration.

In fact a continuous water column flows from xylem of roots, xylem of stem and finally to xylem of leaves.

This water column does not break due to cohesion force (attraction force which exists between water molecules). Evaporation of water molecules from the cells of the leaf creates a suction force which pulls water from xylem cells. Thus, cohesion force and transpiration pull help in the upward movement of sap or water from roots to leaves.

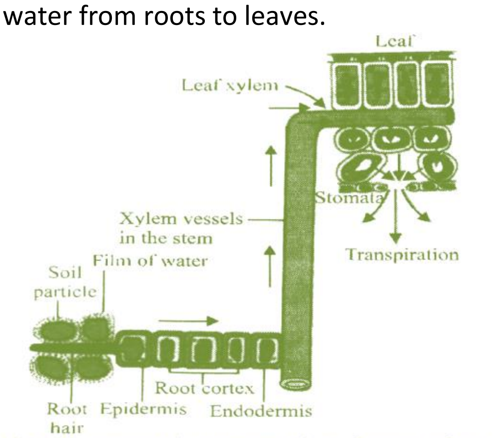


Fig.: Diagrammatic representation of ascent of sap.

TRANSPIRATION

The loss of water in the form of vapours from the aerial parts of a plant (specially leaves) into the atmosphere is called transpiration,

Transpiration mainly occurs through stomata, but it may also occur through cuticle and lenticels.

- **Cuticular transpiration:** Cuticle is a waxy covering on the epidermis of leaves and green stem. Up to 10% of total transpiration may take place through it.
- **Lenticular transpiration:** Lenticles are minilte pores in the bark of stem. Loss of water through them is known as lenticular transpiration. Very small percentage of transpiration takes place through lenticles.
- **Stomatal transpiration:** Stomata are minute pores in the epidermis. Their opening and closing is controlled by guard cells. About 80-90% of water is evaporated through stomata.

ACTIVITY CORNER

To demonstrate the phenomenon of transpiration.

Materials required: One pot with a plant growing in it (A), one pot of approximately similar size having same amount of soil (B), a stick of the size of plant, plastic sheath, oil cloth.

Procedure: Put the thoroughly watered potted plant (A) in sunlight. Insert the stick in the soil of the other pot and put it in sunlight (B). Cover the open area of soil of both the pots with the help of oil cloth to avoid surface evaporation. Now cover both the sets (one with the plant and the other with a stick) with transparent plastic sheaths. Observe after half an hour

Observations: Small drops of water start appearing on the inner side of the plastic sheath which is covered over the plant. No drops of water appear in case of put with stick. The experiment demonstrates that the leaves lose water in the form of vapors which get condensed on the inner surface of sheath.

TRANSLOCATION

Translocation The product of photosynthesis (food molecules) enters the phloem elements from mesophyll cells. The phloem cells transport this soluble food materials to all parts of plants. This transport of food from leaves to different parts of plant is termed as translocation.

Components of phloem are sieve tubes, companion cells, phloem parenchyma and phloem fibres. Sieve tubes are living cells which contain cytoplasm but no nucleus. Companion cells have cytoplasm as well as nucleus and they supply sieve tubes with some of their requirements.

The food is manufactured in the mesophyll cells (or photosynthetic cells) of a leaf. The manufactured food that enters into sieve tubes of the phloem and transported as a dilute aqueous solution may be in upward or downward direction. Food is transported to all non-green parts of the plant for growth and metabolic activities. Beside food molecules, phloem also transports amino acids, hormones synthesized in the shoot tips and root tips and other metabolites.

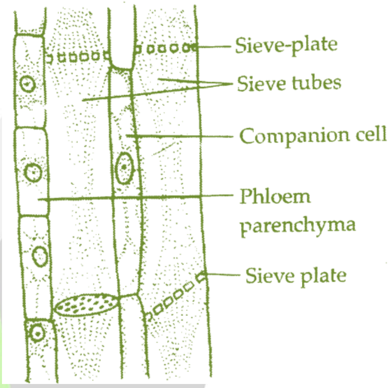


Fig. L.S. of the phloem

Unlike ascent of sap which is largely due to physical forces, the translocation in phloem is achieved by utilizing energy.

In this process glucose is transferred to phloem tissue using energy from ATP. This increases the osmotic pressure of the tissue causing the water to move into it (endosmosis). Soluble material is then transferred from phloem tissue to other tissues which have less pressure than in the phloem. Thus, according to plant's requirement, the material is translocated from higher osmotic pressure areas to lower osmotic pressure areas.

TRANSPORT SYSTEM IN HUMAN

All parts of multicellular organisms need a supply of different substances like oxygen, nutrients, etc. and the removal of metabolic wastes produced in them. Thus, the essential requirement of an organism is the transport of materials from the parts of the body where they are formed or taken up to other parts where they are consumed/needed or get rid of. This function is performed by some extracellular fluids which flow throughout the body. This flow is called circulation and the structures concerned with this circulation constitute Circulatory System or Transport System.

Transport system or circulatory system in human beings consists of:

- A pumping organ - heart
- System of blood vessels - arteries and veins
- Circulatory medium - blood and lymph.

Pumping organ - Heart

The heart is a hollow muscular pumping organ about the size of one's fist. It lies obliquely in the thorax between the lungs immediately above the diaphragm. Its lower conical part is tilted to the left. It is enclosed in a bony cage formed of ribs, backbone and sternum bones.

Heart is enclosed in a double-layered membranous sac called pericardium. Between the two layers of pericardium lies the pericardia injury and friction.

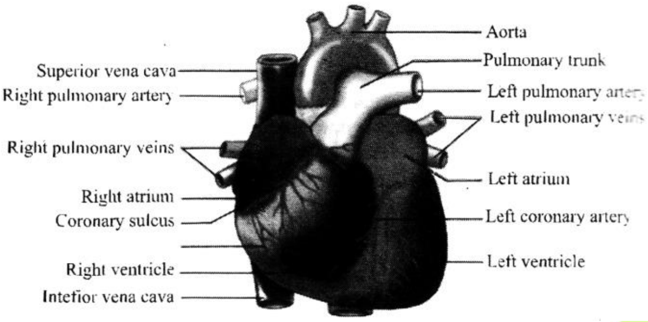


Fig. External features of human heart.

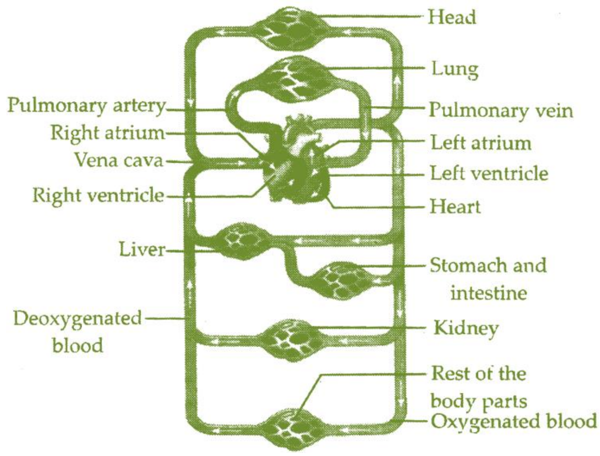
Human heart is divided into right and left half. Each half consists of upper thin-walled atrium or auricle and lower comparatively thick-walled ventricle. The auricles are receiving chambers and ventricles act as pumping chambers. Walls of auricles are thinner because they have to receive the blood, while walls of ventricles are thick because they have to pump the blood.

Four chambers of the heart are left auricle, left ventricle, right auricle and right ventricle.

Auricles are externally demarcated from ventricles by an irregular groove called coronary sulcus.

The ventricles are externally demarcated by an oblique groove known as interventricular sulcus. Internally the two auricles are separated by interauricular septum while partition between two ventricles is known as interventricular septum.

Left auricle receives oxygenated blood from lungs by pulmonary veins. Right auricle receives the deoxygenated blood from upper and lower parts of the body by superior vena cava and inferior vena cava, respectively. Auricles relax while receiving the blood (auricles are said to be in a diastole condition).



Net both the auricles contract (auricles are said to be in a systole condition). The Fig.: Circulation of blood in human body blood from left auricle is passed to left ventricle through the opening guarded by bicuspid valve (valve having two cusps or flaps) or mitral valve. Similarly the blood from right auricle is passed to right ventricle, the opening is guarded by tricuspid valve. Both the ventricles relax while receiving the blood from the auricles.

Then both the ventricles contract (ventricular systole), both bicuspid and tricuspid valves close, so that blood can't move back to auricles. Oxygenated blood from left ventricle is passed to the body by aorta (largest artery) and deoxygenated blood from right ventricle is passed to lungs for oxygenation by pulmonary aorta, which divides into left and right pulmonary artery. At the base of each aorta and pulmonary aorta are present three semilunar cusps (semilunar valves) which prevent backward flow of blood from aorta.

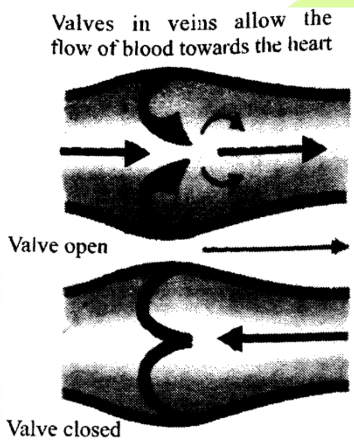
Vertebrate heart

The separation of right and left sides of heart is useful to keep oxygenated deoxygenated blood from mixing. Such a supply is useful for animals which have to use energy constantly to maintain their body temperature like birds and mammals. The animals which do not use energy to maintain their body temperature and their body temperature varies with environmental temperature like, amphibians have three-chambered heart and tolerate some mixing of oxygenated and deoxygenated blood. Fishes have only two chambered heart. The deoxygenated blood is pumped to the gills, where it is oxygenated and directly passed to the body parts.

Thus, in fishes blood is passed only once to the heart in one circulation. In human beings deoxygenated blood is passed to heart, then it is oxygenated in lungs and carried back again to heart. From heart, oxygenated blood is passed to all body parts. Thus, blood flows twice in heart during each cycle. This is known as double circulation.

System of vessels - Arteries and Veins

Blood vessels are a system of channels through which blood flows. Blood vessels are of three kinds, namely arteries, veins and capillaries.
Arteries are the blood vessels which carry blood from heart to various parts of the body. All arteries (except pulmonary artery) carry oxygenated blood. Pulmonary arteries carry deoxygenated blood from right ventricle to lungs.
Arteries have thick, elastic and muscular walls. They are not provided with valves. In arteries blood flows under pressure and with jerks.
Veins carry blood from body parts towards the heart. All veins (except pulmonary veins) carry deoxygenated blood. Pulmonary veins carry oxygenated blood from lungs to left auricle. Veins have thin, less elastic and muscular walls in comparison to arteries.
The lumen of veins are provided with valves to prevent the back flow of blood.



Capillaries are fine microscopic vessels. Arteries branch out into smaller and smaller arterioles which finally form capillaries. These capillaries join to form venules, veins and finally vena cava. Wall of capillaries is one cell thick. Through these thin walls, oxygen and carbon dioxide, dissolved food and excretory products are exchanged with tissues.

Measuring blood pressure

Blood pressure is the pressure against the wall of blood vessels produced by the discharge of blood into them by contraction of the left ventricle. The blood pressure is high in the arteries. In gradually drops in the capillaries, and becomes very low in the veins. Fluids always flow from area of high pressure to areas of lower pressure.

Blood pressure is generally measured by determining the millimeters of mercury (Hg) displaced in a pressure gauge called sphygmomanometer. A common sphygmomanometer has an inflatable bag-like cuff, a compressible bulb, a screw for releasing pressure, a mercury manometer and two rubber tubes connecting the bulb and manometer with cuff. Cuff is wrapped around the upper arm and is rapidly inflated with a hand pump. The sound of blood flow can be heart through a stethoscope. This sound of blood rushing through the arteries at peak pressure is due to vermicular contraction. This indicates systolic blood pressure (120 mm of Hg). A screw is used for releasing pressure, and pressure in cuff continues to drop. The sound fades, until it stops. The reading indicates the diastolic blood pressure (80 mm of Hg). The normal blood pressure of a human being is written as $\frac{120}{80}$.

Blood

Blood is a liquid connective tissue. Blood has a fluid matrix called plasma and three kinds of blood corpuscles suspended in it.

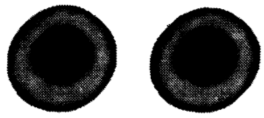
Plasma

It is pale coloured fluid which contributes 55% of blood volume. Plasma contains 90 to 92% of water and 8 to 10% of the following substances:

- Plasma proteins mainly albumin, globulins and fibrinogen.
- Nutrients like glucose, amino acids, fatty acids and glycerol.
- Respiratory gases like oxygen and carbon dioxide.
- Excretory substances like ammonia, urea, uric acid, creatinine, etc.
- Mineral ions such as $Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, PO_4^{3-}$.
- Enzymes, hormones, antibodies.

Blood corpuscles

They from 45% of blood and remain suspended in blood plasma. These are of three types: Red blood corpuscles (RBCs) or erythrocytes, white blood corpuscles (WBCs) or leucocytes and blood platelets or thrombocytes.



Red blood corpuscles


Granulocyte └ Agranulocytes ┘
White blood corpuscles


Blood platelets

Fig. Blood corpuscles in human blood

- **Red blood corpuscles:** These are biconcave disc-like structures. Their number is 5 to 5.5 million/mm3 in human males and 4.5 to 5 million/mm3 in human females. They contain iron pigment haemoglobin, which impart red colour to the blood. RBCs are manufactured in bone marrow. Their life-span is about 120 days after which they are destroyed by liver and spleen. Their small size helps in absorbing oxygen and enables them to travel in very fine blood capillaries throughout the body of a person.
- **White blood corpuscles:** These are nucleated and amoeboid cells. Leucocytes are of two types - granulocytes containing granular cytoplasm and lobed nucleus and agranulocytes, containing smooth cytoplasm and unlobed nucleus. Leucocytes are capable of squeezing out of capillaries to destroy foreign matter. WBCs also manufacture antibodies, which fight against disease-causing germs and are responsible for immunity. In fact white blood corpuscles are called soldiers of the body. They are manufactured in bone marrow.
- **Blood platelets:** These are small, disc-like bodies. These are enucleated and are manufactured in the bone marrow. They are $2.5-3.5\times10^5 / \text{mm}^3$ in number. When we get some injury and blood vessel is ruptured, the blood flows through it. If bleeding does not stop, the excessive loss of blood may lead to death. To avoid this situation, the body has its own natural device. The blood loss is prevented by forming a blood clot which plugs the injury and checks the blood leakage. The platelets play a major role in forming the blood clot.

Lymph

When blood flows into thin capillaries some amount of plasma filters out of thin capillaries. This fluid is called interstitial fluid or tissue fluid or lymph. As it bathes the cells and lies outside the cells, lymph is also called extracellular fluid. It is colourless and contains lymphocytes.

Unlike blood, lymph does not contain red blood corpuscles, platelets and plasma proteins.

Lymph flows only in one direction that is from tissues to heart.

From the intercellular space, lymph drains into lymphatic capillaries, which join to form large lymph vessels that finally open into larger veins.

The functions of lymph are as under:

- It transports fatty acids and glycerols from small intestine to blood.
- Lymphocytes present in it destroy harmful pathogens.
- It drains excess tissue fluid from intercellular spaces back into the blood.
- It carries lymphocytes and antibodies from lymph nodes to the blood.
- Lymph nodes localize the infection and prevent it from spreading to other body parts.

Lymph vessels along with lymph nodes and lymph glands constitute lymphatic system.

Table: Differences between blood and lymph.

Characteristic	Blood	Lymph
1. Colour	Red in colour	Colourless
2. Components	• Consists of plasma, erythrocytes, leucocytes and platelets. • Contains several plasma proteins and high concentration of calcium and phosphorus.	• Consists of plasma and leucocytes only. • Contains fewer plasma proteins and low concentration of calcium and phosphorus.
3. Flow	Flow rapidly.	Flow is very slow.
4. Direction of flow	Path of circulation is heart to body organs and from body organs back to heart.	Path of circulation is body tissues to heart.

ILLUSTRATION

23. What are the components of the transport system in human beings? What are the functions of these components?

Ans. The components of the human transport system are – blood vascular system and lymphatic system.

Blood vascular system: It consists of heart, blood vessels and blood.

(i) Heart: It is a muscular pumping organ which keeps the circulating medium (blood) in a state of contiguous movement.

(ii) Blood vessels: These are channels through which blood flows. Blood vessels are of three types.

(a) Arteries: They carry oxygenated blood from the heart to different parts of the body.

(b) Veins: They transport deoxygenated blood from different parts of the body back to the heart.

(c) Capillaries: Help in exchange of material between blood and living cells through tissue fluid.

(ii) Blood: It consists of plasma and corpuscles ($RBCs, WBCs$ and platelets)

(a) Plasma: It is the liquid part of the blood which helps in transport of hormones, nutrients, excretory matter, etc.

(b) RBCs: Help in transport of respiratory gases $-O_2$ and CO_2.

(c) WBCs. Act as soldiers of the body

(d) Platelets: Help in blood clotting.

Lymphatic system: It is a network of thin walled vessels. It consists of lymph, lymphatic vessels and lymph nodes.

(i) Lymph: Helps in transport of respiratory gases, fatty glycerol, vitamins, etc. inside body.

(ii) Lymphatic vessels: Collect lymph and transport it to the veins.

(iii) Lymph node: Helps in formation of lymphocytes.

24. Why is it necessary to separate oxygenated and deoxygenated blood in mammals and birds?

Ans. Mammals and birds are warm-blooded animals. The metabolic rate of their body is higher than those of the other animals and so such their energy requirement is also more. For this, they need energy to maintain the body temperature. Thus, it is necessary to separate oxygenated and deoxygenated blood so that the required amount of oxygen could be available to the cells and tissues.

25. What are the components of the transport system in highly organized plants?

Ans. Transport system in highly organized plants consists of two main components – xylem and phloem.

(i) Xylem: It is responsible for transport of water and minerals and its components are – xylem vessels, xylem tracheids, and xylem parenchyma and xylem fibres

(ii) Phloem: It is responsible for transport of blood substances and its components are – sieve tubes, companion cells, and phloem parenchyma and phloem fibres.

26. How are water and minerals transported in plants?

Ans. The upward movement of water and minerals salts from roots of the aerial parts of the plant leaves, shoots, flowers, etc. against the gravitational force occurs through the process of ascent of sap. In xylem tissue, vessels and tracheids of the roots, stems and leaves are interconnected to form a continuous system of water conducting channels reaching all parts of the plant.

The water, along with dissolved minerals from root hairs, passes into xylem vessels though cells of the cortex endodermis and pericycle and then ascent of sap takes place from xylem of the roots to the xylem of stem and leaves through vessels and tracheids. Evaporation of water molecules from the cells of leaves (transpiration) creates a suction which pulls the water from the root towards the upper parts of the plant.

27. How is food transported in plants?

Ans. Food molecules are synthesized in the green parts of the plant (leaves), from where it is transported to all the parts of plant through phloem. Food from the area of its manufacture enters into sieve tubes of phloem and gets transported as a dilute aqueous solution the movement of nutrients may be in upward or downward direction. Companion cells of the phloem help in this process. The transport of food from leaves to different parts of the plant is termed as translocation. The transport of nutrients occurs through physical forces but enter and exit of nutrients from the phloem occurs only through an active process utilizing energy form ATP. Entry of nutrients into phloem increases the osmotic pressure of the tissue, causing water to move into it due to endosmosis. The pressure moves the material in the phloem to tissues which have less pressure. In this way, according to the plant's requirement, the nutrients get translocated.

28. Why is the fish heart called a venous heart? What type of blood circulation does it represent?

Ans. Fish heart is two-chambered-one auricle and one ventricle. Since the heart always contains deoxygenated (impure) blood, the fish heart is called a venous heart.

Fish heart represents single blood circulation, as the blood passes only once through the heart during a single cardiac cycle.

29. Why are plants growing in arid regions mostly deep rooted?

Ans. Water is unavailable in the top layer of the soil in arid conditions. Therefore, plant roots go deep in the arid soil in order to absorb maximum amount of water. Shallow rooted plants cannot survive in arid zone.

30. Water fails to translocate in gymnosperms. Give reason.

Ans. The xylem vessel system is the princial pathway by which water is translocated in angiosperms. The vessels of xylem tissue form a network of ducts that extends to all parts of the plant and provides an easy accessible supply of water. However, xylem vessels are not present in gymnosperms and in this group, the tracheids form the principal pathway of water translocation.

31. Deficiency of vitamin K causes late clotting of blood. Give reason.

Ans. Prothrombin is an inactive enzyme which is produced continuously from the liver as its life is only 24 hours Vitamin K is necessary for the formation of prothrombin. Without prothrombin, clotting is not possible as its active form, thrombin, converts fibrinogen into fibrin which forms the clot. Hence, vitamin K deficiency causes lesser production of prothrombin, resulting in delayed clotting of blood at the site of wound or damaged tissues.

CONCEPT MAP

Transport of materials in body

The transport of substances like oxygen, food, water, enzymes, hormones, etc. inside the body of an organism is called internal transport and the organs which carry out this transport within the body together constitute the internal transport system.

Transport

In plants

Plants absorb water and material salts from the soil by their root system. The water and minerals absorbed by the roots are transported through **xylem** tissue, while food prepared by the leaves is transported through **phloem**. The upward movement of water and mineral salts from roots to the aerial parts (leaves, branches, flowers, etc.) of the plant against the gravitational force is called **ascent of sap**.

Transpiration

The loss of water in the form of vapours from the aerial parts of a plant (specially leaves) into the atmosphere is called transpiration.

Translocation

Movement of food from leaves to different parts of plant is termed as translocation.

In humans

The circulatory system is a transport system in humans, carrying oxygen, nutrients, hormones and other substances to the tissues, CO_2 to the lungs and other waste products to the kidneys. A fluid, the **blood** which carries the food materials, oxygen, waste materials etc., is forced by a pump, the **heart,** through a system of tubes, the blood vessels **(arteries and veins)** to the close vicinity of every cell and then back to the heart to be pumped round again and again. **Lymph** is another fluid that transports some materials through the blood to the heart.

EXCRETION

Metabolic activities are going on in the living cells round the clock. During these biochemical reactions, toxic wastes are produced, water content is either increased or decreased, and ionic imbalance may be created. The biological process involved in the removal of toxic wastes from the body of an organism is called excretion.

EXCRETION IN HUMAN

Excretory system in human beings includes:

- **A pair of kidneys:** Kidneys are bean-shaped, reddish brown in colour. The kidneys lie one on either side of the vertebral column in the abdominal cavity attached to the dorsal body wall. On the inner concave side of each kidney is present a notch called hilum. Blood vessels and nerves enter through it and the urine leaves out.

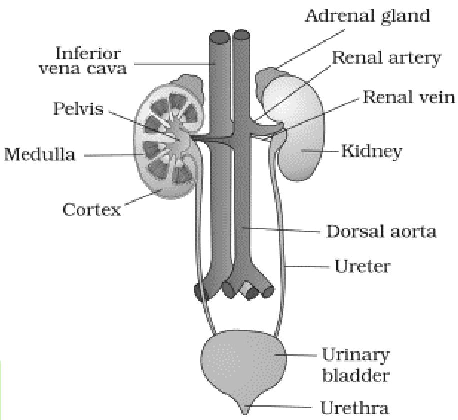


Fig.: Excretory system in human

- **A pair of ureters:** From hilum of each kidney emerges out a slender, whitish tube called ureter. Within the kidney ureter is expanded to form the renal pelvis. Each ureter is about 30 cm long, 3 - 4 mm in diameter and opens into urinary bladder by slit-like aperture.
  The ureters carry urine from kidneys to urinary bladder.
- **A urinary bladder and a urethra:** Urinary bladder is a pear-shaped muscular reservoir for urine. It lies in the pelvic cavity of the abdomen. The neck of urinary bladder is surrounded by sphincters which remain closed and open only at the time of micturition (urination).
  The bladder leads to urethra which opens outside through urethral aperture. In human male urethra is about 20 cm in length and in female it is about 3 - 5 cm in length.

Functional unit of kidney – Nephron

Each kidney consists of more than one million nephrons. Nephron is a functional unit of kidney. Each nephron consists of a cup-shaped structure called Bowman's capsule containing a bunch of capillaries called glomerulus.

These capillaries arise from an artery which brings blood along with waste and excess water from the body to the kidney. Bowman's capsule leads into tubular structure which ultimately joins the transverse collecting tubule.

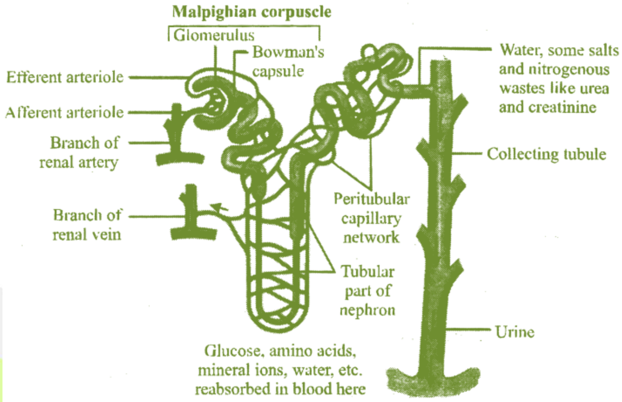


Fig.: Various parts of a nephron.

The blood along with waste and excess water is brought to kidney by renal arteries. Blood is filtered from the blood capillaries into Bowman's capsule. As the nephric filtrate passes through the tubular part of nephron, useful substances like glucose, amino acid, mineral ions, water, etc. are reabsorbed by blood capillaries surrounding the nephron. From nephron nitrogenous waste is drained into renal pelvis which leads to ureters. Ureters carry this nitrogenous waste which is mainly urea into the urinary bladder. When bladder gets filled with urine, it is passed out through urethra. A healthy person excretes 1-2 litres of urine per day.

Thus, kidneys perform two vital functions:

- Filtering out nitrogenous waste from the blood.
- Osmoregulation, i.e., maintaining right amount of water and ionic balance in the body.

WORKING OF NEPHRON

Main function of nephron is to form urine. The three main processes involved in the urine formation are:

GLOMERULAR ULTRAFILTRATION

- It is the filtration of body fluids and solutes from the blood, out of the glomerular capillaries into

the Bowman's capsule due to the pressure of the glomerulus.
- All substances from the blood are filtered out except the large protein molecules. This fluid in the glomerular capsule is called glomerular filtrate.
- It consists of water, urea, salts, glucose and other plasma solutes.
- About 180 litres of glomerular filtrate is formed by both kidneys in a day but urine excreted is about 1-2 litres a day. This shows that most of glomerular filtrate is reabsorbed.

Tubular Reabsorption

- Glomerular filtrate contains a lot of useful materials like glucose, salts such as that of sodium and water.
- These substances are reabsorbed by blood capillaries surrounding the nephron from the renal tubule at various levels and in varied proportions.

Tubular secretion

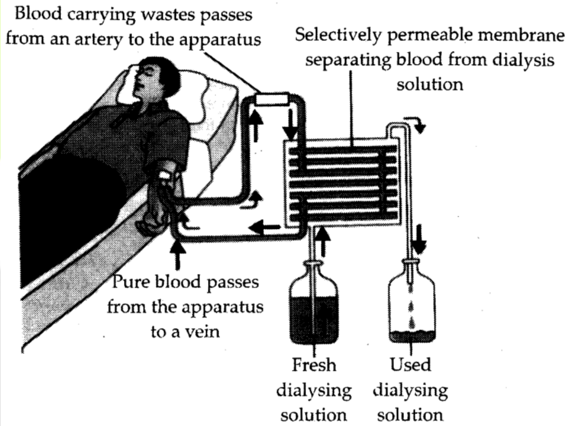
- This occurs mainly in the renal tubule and the collecting duct of the nephron.
- It is an active, vital process performed by the cells of the cuboidal epithelium lining the tubules which excrete additional wastes from the blood stream into the filtrate by active transport.
- In this process substances like potassium, hydrogen, creatinine and certain drugs like phenol, penicillin etc., are directly excreted by the tubular cells from the blood.
- The fluid which now flows through collecting tubule is urine which consists of water, urea, uric acid, mineral ions like sodium, potassium, chloride, phosphates etc.

Osmoregulation

- Kidneys while removing wastes from the blood also regulates its composition i.e., percentage of water and salts. This is called osmoregulation.
- When water is abundant in the body tissues, large quantities of dilute urine is excreted out and vice versa.
- It is mainly brought about under the influence of certain hormones which control the movement of water and sodium ions into and out of the nephron.
- The exact amount reabsorbed (i.e., the volume of urine formed), is controlled by the antidiuretic hormone (ADH) or vasopressin hormone of the posterior lobe of the master gland (pituitary) of the body.
- Increase in amount of water in the blood increases the blood volume and decreases the amount of ADH released from the pituitary gland which in turn lowers the permeability of DCT as well as that of collecting tubules and thus, decreasing reabsorption of water from them.
- Similarly if less amount of water is there in blood, more of ADH will be released. This will lead to increase in permeability of DCT and those increase in reabsorption of water.

Artificial kidney and haemodialysis

Partial or total inability of kidneys to carry on excretory and salt-water regulatory function is called renal or kidney failure. It occurs due to infection, injury or restricted blood flow to kidneys.
In such cases blood urea rises abnormally which can even lead to death. For this an artificial kidney is used to filter the blood of a patient. The patient is said to be put on dialysis and the process of purifying blood by an artificial kidney is called haemodialysis.



Process of haemodialysis

- Blood of the patient is taken out from main artery, cooled to 0°C and mixed with anticoagulant such as heparin.
- Blood is pumped into an apparatus called artificial kidney. In this apparatus blood flows through channels or tubes having semipermeable membrane of cellophane.
- Cellophane tubes are kept in a dialyzing fluid which contains some small solutes and mineral ions. As the blood flows through these cellophane tubes, nitrogenous wastes like urea, uric acid, creatinine, etc. diffuse out in dialyzing fluid.
- The blood that comes out of artificial kidney is pure blood. It is then warmed to body

temperature and mixed with antiheparin to restore its normal coagulability and returned to a vein of patient.

- Haemodialysis serves and prolongs the life of uraemic patients.

Accessory excretory organs

Liver

- Urea is formed in the liver which is eliminated through kidneys. Liver cells also degrade the hemoglobin of worn out red blood corpuscles into bile pigments (bilirubin and biliverbin).
- Liver cells also excrete cholesterol, certain products of steroid hormoners, some vitamins and many drugs. Liver secretes these substances in the bile. The bile carries these substances to the intestine and are passed out with faeces.

Skin

- Skin plays a major role in excretion. In helps the body to get rid of excess of water, salts and waste such as ammonia in aquatic animals.
- The mammalian skin possesses sweat glands and sebaceous glands that play excretory roles.

Intestine

- Epithelial cells of colon excrete excess salts of calcium, magnesium and iron along with faeces

Lung

- It helps in removing gaseous from of excretory wastes like CO_2 and a little amount of water vapor.

Salivary glands

- Heavy metals and drugs are excreted in the saliva.

EXCRETION IN PLANTS

In plants also, certain metabolic waste products are formed which have to be expelled out. The system of expelling these wastes is different from animals.

- Photosynthetic and respiratory wastes like O_2 and CO_2 are expelled out through stomata. CO_2 is either utilized by plants for photosynthesis or expelled out.
- Excess of water is eliminated by the process of transpiration.
- Waste products may be stored in leaves, bark or any other part of plant which fall off or get rid off by the plants.
- In some plants, the metabolic end-products are set aside in the form of crystals.
- Several plant products like resins, tannins, alkaloids like morphine, quinine are also plant wastes, although they are useful to us.

ILLUSTRATION

32. Describe the structure and functioning of nephrons.

Ans. Nephrons are the structural and functional units of the kidneys. Each nephron is tubular structure bearing a cup-like structure called Bowman's capsule at its free end. In the cup of capillaries called glomerulus. The Bowman's capsule continues into the renal tubules.

The function of nephron is filtration of blood and elimination of waste materials. Blood along with waste materials, is brought to glomerulus through afferent arteries. The Bowman's capsule filters the blood and pours the filtrate into the renal tubule, in which useful substances and a large amount of water is reabsorbed by blood capillaries surrounding it. Nitrogenous and other wastes, along with a little amount of water, is sent to the urinary bladder through the ureters. The urinary bladder expels the urine to the outside through the urethra.

33. How is the amount of urine produced regulated?

Ans. The amount of urine produced is regulated by a hormone secreted from the posterior pituitary gland. This hormone is named as antidiuretic hormone (ADH) or vasopressin. The function of this hormone is to reabsorb water from the nephric filtrate.

In enough water is present in blood, smaller amount of ADH is secreted and more nephric filtrate is formed. If less amount of water is present in the blood, more ADH will be secreted more water will be reabsorbed from the nephric filtrate by blood capillaries surrounding the nephron, and hence less urine will be produced.

34. If human strongly allowed to stand for some time, it smells strongly of ammonia. Why?

Ans. Urea is the chief nitrogenous constituent of human urine. When the urine is allowed to stand for some time, the bacterial degradation occurs and it leads to the production of ammonia from urea. Thus, it smells strongly of ammonia.

$$\underset{urea}{NH_2-CO-NH_2} \xrightarrow[\text{degradation}]{\text{Bacterial}} \underset{\text{ammonia}}{NH_3} + \underset{\text{carbonic acid}}{HCO_3}$$

35. What will happen if a single kidney is removed from the body of a man?

Ans. Nature has provided us two kidneys. A single kidney is sufficient to excrete the nitrogenous wastes from out body. If a single kidney is removed, as occurs in case of kidney donation, the person will survive and will lead a normal life.

36. How can haemodialysis save and prolong the life of uremic patients?

Ans. The blood urea level rises abnormally (uremia) in patients suffering from renal failure. In uremic patients, an artificial kidney is used for removing accumulated waste products like urea from the blood by a process called haemodialysis. During the process, the patients blood is made to pass through the dialysis machine which filter out the waste material from blood, and the blood is again transfused into the patient's body. Dialysers work exactly on the principle of kidney. Haemodialysis performed twice or thrice a week can save and prolong the life of uremic patients.

37. What are the methods used by plants to get rid of excretory products?

Ans. The various methods used by plants to get rid of excretory products are:

Photosynthetic and respiratory wastes like

O_2 and CO_2 are expelled out through stomata. CO_2 is either utilized by plants for photosynthesis or expelled out.

Excess of water is eliminated by the process of transpiration.

Waste products may be stored in leaves, bark or any other part of plant which falls off or get rid off by the plants.

In some plants, the metabolic end-products are set aside in the form of crystals.

Several plant products like resins, tannins, alkaloids like morphine, quinine are also plant wastes, although they are useful to us.

38. It has been observed that birds drink very little water as compared to human beings in terms of body weight ratio. Why?

Ans. Birds are uricotelic, i.e., their excretory wastes are in the form of uric acid. Uric acid is far less toxic in comparison in water, does not require much water for its elimination. Hence, birds drink very little water.

39. Does the liver have any role in excretion?

Ans. The liver is the principal organ for the excretion of cholesterol, bile pigments, some vitamins and many drugs. It secretes these substances in the bile. Bile brings them to the intestine from where they are eliminated with faces. Moreover, liver is the centre of urea formation, which is the main metabolic waste of nitrogenous substances.

CONCEPT MAP

Excretion

The biological process involved in the removal of toxic waste from the body of an organism.

Excretion in human beings

Working of nephron

- Glomerular ultrafiltration
- Tubular reabsorption
- Tubular secretion

A pair of kidneys

Kidneys are bean-shaped, reddish brown in colour. The kidneys lie one on either side of the vertebral column in the abdominal cavity attached to the dorsal body wall. Each kidney consists of more than one million **nephrons** which are functional units of kidney. Kidneys are also involved in osmoregulation.

A pair of ureters

From hilum of each kidney emerges out a slender, whitish tube called ureter. Within the kidney ureter is expanded to form the renal pelvis.

A urinary bladder and urethra

Urinary bladder is a pear-shaped muscular reservoir for urine. It lies in the pelvic cavity of the abdomen.

Excretion in plants

- Photosynthetic and respiratory wastes like O_2 and CO_2 are expelled out through stomata.
- Excess of water is eliminated by the process of transpiration.
- Several plant products like resins, tannins, alkaloids like morphine, quinine are also plant wastes, although they are useful to us.

ESSENTIAL POINTS For COMPETITIVE EXAMS

DENTAL CARIES

- The tooth decay begins when bacteria (Streptococcus mutans) grow on food particles especially sugars sticking to the teeth and produce acids. The acids act upon the tooth and cause softening or demineralization. The bacterial colony grows in size and forms a dental plaque. Regular brushing the teeth after meals removes the plaque.

DISORDERS OF CIRCULATORY SYSTEM

- **High Blood Pressure (Hypertension):** Hypertension is the term for blood pressure that is higher than normal (120/80). In this measurement 120 mm Hg (millimeters of mercury pressure) is the systolic, or pumping pressure and

80 mm Hg is the diastolic, or resting pressure. If repeated checks of blood pressure of an individual is 140/90 or higher, it shows hypertension. High blood pressure leads to heart diseases and also affect vital organs like brain and kidney.

- **Coronary Artery Disease (CAD):** Coronary artery disease, often referred to as atherosclerosis, affects the vessels that supply blood to the heart muscle. It is caused by deposits of calcium, fat, cholesterol and fibrous tissues, which makes the lumen of arteries narrower.
- **Angina: It is also called 'angina pectoris'.** A symptom of acute chest pain appears when not enough oxygen is reaching the heart muscle. Angina can occur in men and women of any age but it is more common among the middle-aged and elderly. It occurs due to conditions that affect the blood flow.
- **Heart failure:** Heart failure means the state of heart when it is not pumping blood effectively enough to meet the needs of the body. It is sometimes called congestive heart failure because congestion of the lungs is one of the main symptoms of this disease. Heart failure is not the same as cardiac arrest (when the heart stops beating) or a heart attack (when the heart muscle is suddenly damaged by an inadequate blood supply).

DISORDERS OF RESPIRATORY SYSTEM

- **Asthma** is a difficulty in breathing causing wheezing due to inflammation of bronchi and bronchioles.
- **Emphysema** is a chronic disorder in which alveolar walls are damaged due to which respiratory surface is decreased. One of the major causes of this is cigarette smoking.
- Occupational respiratory disorders: In certain industries, especially those involving grinding or stone-breaking, so much dust is produced that the defense mechanism of the body cannot fully cope with the situation. Long exposure can give rise to inflammation leading to fibrosis (proliferation of fibrous tissues) and thus causing serious lung damage. Workers in such industries should wear protective masks.

DISORDERS OF THE EXCRETORY SYSTEM

- Renal calculi: Stone or insoluble mass of crystallized salts (oxalates, etc.) formed within the kidney.
- Glomerulonephritis: Inflammation of glomeruli of kidney.
- Kidney transplantation is the ultimate method in the correction of acute renal failures (kidney failure). A functioning kidney is used in transplantation from a donor, preferably a close relative, to minimize its chances of ejection by the immune system of the host. Modem clinical procedures have increased the success rate of such a complicated technique.

COMPOSITION OF URINE

Normal urine is a yellow fluid. It is usually slightly acidic with pH value 6. Its main components are:

- 96% of urine is water.
- Urea is the most abundant dissolved substance, forming 2% of the urine. Other dissolved organic compounds are creatinine and urates, which are the end products of protein metabolism.
- Sodium chloride is the most abundant salt, forming 1%.
- The main ions of inorganic salts in urine are sodium, potassium, magnesium, calcium, chloride, phosphate, sulphate and oxalate.
- Traces of pigments derived from bile pigments are present. Perhaps this is the origin of colouring matter of urine.
- Many hormones are passed out in the urine, and, if in excess, may indicate over activity of an endocrine gland.

STRUCTURE OF TEETH

- Teeth are embedded in the jaws. Man has a fixed upper jaw and a movable lower jaw. Each tooth consists of three parts: crown, neck, root.

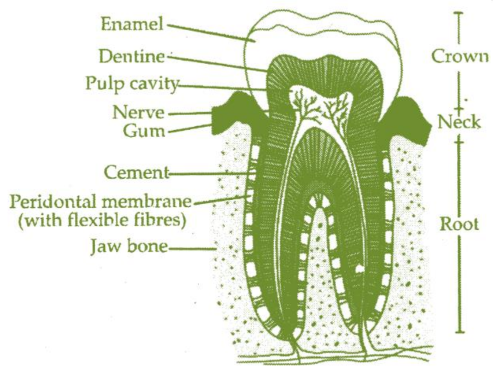


Fig.: Molar (LS).

- **Crown** - It is the exposed portion of tooth above the gums (gingiva). The gingiva is a specialized region of the oral mucosa surrounding the neck of the teeth.

- Crown is covered with the hardest substance called enamel that protects the crown.
- **Neck** - It is a narrow portion at the gumline.
- **Root** - It is embedded in the jaw bone and holds the tooth securely in place.
- Beneath the enamel is present dentine (secreted by odontoblast) which is made up of a hard substance similar to bone. It is also tough but not as tough as enamel and can decay It has numerous canaliculi that pass radially from the pulp cavity towards the enamel.
- Dentine is regenerable living tissues.
- Dentine forms the bulk of the tooth. There is a pulp cavity inside the dentine. It is a jelly like substance and carries the nerves fibres, blood vessels and sensory cells.
- The root is fixed in the alveolus of the jaw bone by peridontal membrane and cementum.
- There are two main types of cells, these are dentine forming odontoblasts and enamel forming ameloblasts.
- **Cement** - It is a bone like hard substance around the root that holds a tooth in its socket and peridontal membrane covers the cement. These are live cells.

SALIVARY GLANDS

- There are three pairs of salivary glands: parotid, sublingual and submaxillary or submandibular.
  (i) Parotid glands: These are the largest salivary glands. They lie on the sides of the face, 'just below and in front of the ears. The parotid ducts, also called Stenson's ducts, open into the vestibule opposite the upper second molar teeth. Viral infection of the parotid glands/causing swelling and pain, is the disease called mumps,
  (ii) Sublingual glands: These lie under the front part of the tongue. The sublingual ducts, also termed ducts of Rivinus, also open under the tongue.
  (iii) Submaxillary glands: These lie at the angles of the lower jaw. The submaxillary ducts, also known as Wharton's ducts, open under the tongue.

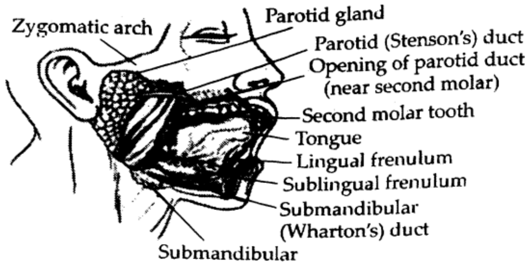


Fig.: Salivary glands

RESPIRATORY VOLUME AND CAPACITIES

We have the ability to increase the strength of inspiration and expiration with the help of additional muscles in the abdomen. On an average, a healthy human breathes 12-16 times minute. The volume of air involved in breathing movements can be estimated by using a spirometer which helps in clinical assessment of pulmonary functions (Refer next page).

LARYNX OR VOICE BOX

- Larynx is also called as voice box. It's present at the opening of trachea.
- Larynx is comprised of nine cartilages. Three are single and three are paired. The single cartilages are epiglottis, thyroid cartilage (supports it from front) and cricoid cartilage. Thyroid and cricoid cartilages consist of hyaline cartilage. Arytenoid cartilage (hyaline and elastic type), corniculate cartilage (elastic) and cuneiform cartilages (elastic) are paired cartilage. All these cartilages together form a box.
- Inside the larynx are the vocal cords. These are 2 pairs of folds of mucous membrane that extend into the lumen from the sides. The upper pair are called false vocal cords and the lower pair are termed true vocal cords.
- The vocal cords are composed of yellow elastic tissue covered by stratified squamous epithelium. The true vocal cords have cord-like free margins which enclose a passage named rima glottidis. The latter puts the larynx in communication with the laryngopharynx above.
- Sound is produced by the true vocal cords.
- For the production of sound, the vocal cords are brought parallel and closer to each other by the action of the pharyngeal muscles.
- Now a curretit of air is passed through them under pressure from the lungs. This sets the vocal cords into vibration, which results in the production of sound. The quality of sound is altered by vibration in the tension of the vocal cords. The buccal cavity, soft palatae, tongue and lips assist the larynx in producing articulate human speech.

LEUCOCYTES (WHITE BLOOD CORPUSCLES OR WBCs)

- The number of leucocytes per micro litre of blood is called the total leucocyte count (TLC). This varies from 5,000 to 10,000 per cubic millimetre of blood in humans.

- Rise in WBC count is termed leucocytosis. Abnormal increase of WBCs is in malignancies like leukemia (blood cancer). Fall in WBC count is called leukopenia.
- The leucocytes are of two main types: agranulocytes and granulocytes.

Agranulocytes

- The granules are not found in the cytoplasm of these cells. The agranulocytes are of two types:
- **Lymphocytes:** They are smaller in size containing scant cytoplasm with large rounded nucleus.

Table: Respiratory volumes and capacities

1.	Total volume (TV)	500 ml	It is the volume of air inspired and expired during normal breathing or in each respiratory cycle without any effort. It is contributed by alveolar volume (350 ml) and dead space volume (150 ml).
2.	Alveolar Volume	350 ml	The alveolar volume is the air that reaches the respiratory surfaces of alveoli and engages in gas exchange.
3.	Dead Space Volume	150 ml	Dead space volume or air is that air which does not reach the respiratory surface, it just fills the respiratory passage.
4.	Inspiratory Reserve Volume (IRV)	2000 ml - 2500 ml	It is an extra amount of air that can be inspired forcibly after a normal inspiration.
5.	Expiratory Reserve Volume (ERV)	1000 ml - 1500 ml	It is an extra amount of air that can be expelled-after a normal expiration.
6.	Residual Volume (RV)	1500 ml	It is the volume of air that always remain in the lungs after forcible expiration. It enables the lungs to continue exchange of gases even after maximum exhalation or on holding the breath.
7.	Vital Capacity (VC)	3,500 ml - 4500 ml	It is the total volume of air inspired and expired to a maximum level. It is the sum total of tidal volume, inspiratory reserve volume and expiratory reserve volume. Thus, VC = TV + IRV + ERV (i) The vital capacity is higher in athletes, mountaineers or mountain-dwellers and lower in non-athletes, people living in plains, women, old individuals, cigarette smokers. (ii) Higher the vital capacity, higher is the amount of air exchanged in each breath.
8.	Inspiratory Capacity (IC)	2,500 ml -3,000 ml	It is the total volume of air that can be inhaled after a normal expiration. It includes tidal volume and inspiratory reserve volume (1C = TV + IRV).
9.	Functional Residual Capacity (FRC)	2,500 ml - 3,000 ml	It is the sum total of residual volume and the expiratory reserve volume (FRC = RV + ERV).
10.	Total Lung Capacity (TLC)	5,000 ml- 6,000 ml	It is the total amount of air present in the lungs and the respiratory passage after a maximum inspiration. It is the sum total of vital capacity and the residual volume. TLC = VC + RV or TLC = TV + IRV + ERV + RV.

11.	Alveolar ventilation	4,200 ml	It is the rate at which the fresh air reaches the alveoli and adjoining areas like alveolar ducts, alveolar sacs and respiratory bronchioles. It is calculated as: Alveolar ventilation per minute = Rate of respiration x (TV - Dead Space volume) = 12 x (500 - 150) == 12 x 350 = 4200 ml/minute

They are nonmotile and nonphagocytic. They produce antibodies to destroy microbes Lymphocytes exist in two major groups in circulation. These are B- and T-lymphocytes.

Monocytes: They are the largest of all types of leucocytes and somewhat amoeboid in shape. They have much cytoplasm and the nucleus is bean-shaped. They are motile and phagocytic in nature and engulf bacteria and cellular debris.

Granulocytes

- They contain granules in their cytoplasm. Their nucleus is irregular or lobed or subdivided. According to their staining property, the granulocytes are divided into three types.

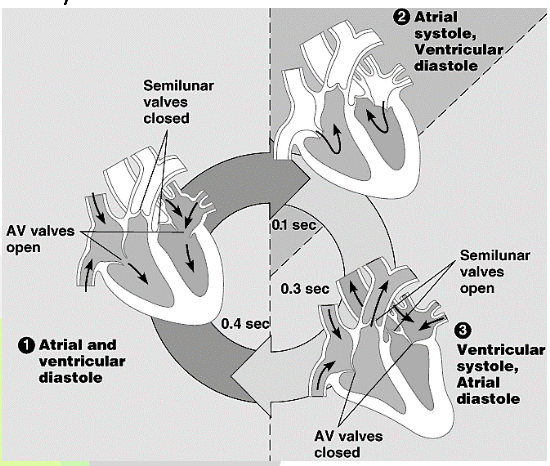
  (i) Eosinophils: They have bilobed nucleus and coarse granules that take acidic stains (e.g., eosin). Their number increases in people with allergic conditions. They are nonphagocytic and seems to play a role in the immune system. The coarse granules contain hydrolytic enzymes and peroxidase which are discharged into the phagosome.

  (ii) Basophils have nucleus which is three lobed and have less number of coarse granules.
  Their granules take basic stain and release heparin, histamine and serotonin.

  (iii) Neutrophils stain equally well with both basic and acidic dyes. They are quite large and have many lobed nucleus and abundant granules. Neutrophils are phagocytic in nature and are the most numerous of all leucocytes. Certain neutrophils in female mammals possess a small spherical lobe attached to their nucleus by a stalk. This lobe is called drum stick (= sex chromatin) or Barr body.

CARDIAC CYCLE

- The cardiac cycle consists of one heart beat or one cycle of contraction and relaxation of the cardiac muscle. The contraction phase is called the systole while the relaxation phase is called the diastole.
- When both the atria and ventricles are in diastolic or relaxed phase, this is referred to as a joint diastole. During this phase, the blood flows from the superior and inferior venae cavae into the atria and from the atria to the respective ventricles through auriculo ventricular valves. But there is no flow of blood from the ventricles to the aorta and pulmonary trunk as the semilunar valves remain closed.
- The successive stages of the cardiac cycle are briefly described below.



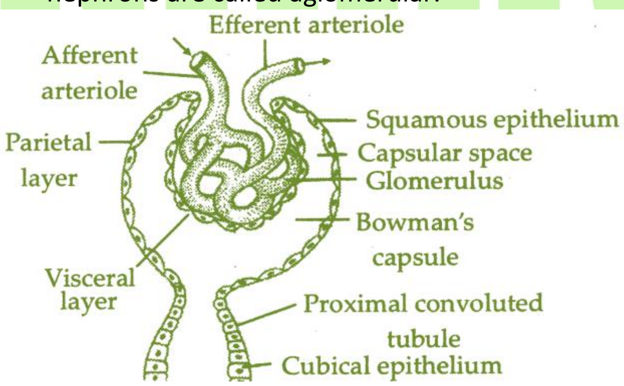
- **Atrial systole:** The atria contract due to wave of contraction, stimulated by the SA node. The blood is forced into the ventricles as the bicuspid and tricuspid valves are open.
- **Beginning of ventricular systole:** The ventricles begin to contract due to a wave of contraction, stimulated by the AV node. The bicuspid and tricuspid valves close immediately producing part of the first heart sound.
- **Complete ventricular systole:** When the ventricles complete their contraction, the blood flows into the pulmonary trunk and aorta as the semilunar valves open.
- **Beginning of ventricular diastole:** The ventricles relax and the semilunar valves are closed. This causes the second heart sound.
- **Complete ventricular diastole:** The tricuspid and bicuspid valves open when the pressure in the ventricles falls and blood flows from the atria into the ventricles. Contraction of the heart does not cause this blood flow. It is due to the fact that the pressure within the relaxed ventricles is less than that in the atria and veins.

STRUCTURE OF NEPHRON OR URINIFEROUS TUBULE

- Nephrons or uriniferous tubules are morphological and physiological units of kidneys.
- Two types of nephrons present in kidney are: cortical and juxtamedullary nephrons.
- Cortical nephrons (about 85%) lie in the renal cortex their glomeruli lie in outer cortex.
  They have a shorter loop of Henie and peritubular capillary network. They do not have vasa recta and control plasma volume when water supply is normal.
- Juxtamedullary nephrons (about 15%) lie at the junction of renal cortex and medulla, have a longer loop of Henie and vasa recta. They control plasma volume when water supply is short.
- A nephron consists of two parts - an initial filtering component, the renal corpuscle or Malpighian corpuscle and a long tubule, the renal tubule - both made of simple cuboidal epithelium.

Renal corpuscle

- Malpighian corpuscle (= Renal corpuscle) is named after Marcello Malpighi (1628 -1694), an Italian physician and biologist.
- The renal corpuscle filters out large solutes from the blood, and delivers water and small solutes to the renal tubule for modification.
- The renal corpuscle is composed of a capillary network called glomerulus and a Bowman's capsule or glomerular capsule.
- Bowman's capsule and glomerulus are absent in marine fishes and desert amphibians, hence their nephrons are called aglomerular.



Bowman's capsule and glomerulus

- Bowman's capsule is named after Sir William Bowman (1816-1892), a British surgeon and anatomist. It is a double layered, cup-shaped structure. The lumen of capsule is continuous with the narrow lumen of renal tubule. Bowman's capsule consists of two layers-outer parietal layer (consists of simple squamous epithelium) and inner visceral layer (layer of specialized epithelial cells called podocytes containing filtration slits through which filtrate filters).

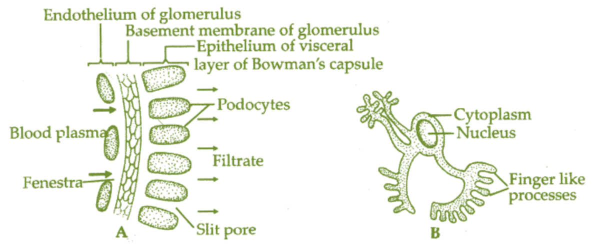


Fig.: Functional structure of the glomerular membrane. B. Structure of podocyte

- **Glomerulus** is a capillary network within the Bowman's capsules. Blood enters glomerular capillaries through afferent arterioles and leaves through efferent arterioles. The diameter of afferent arteriole is much more than that of efferent arteriole.
- The walls of the afferent and efferent arterioles contain the renin-secreting juxtaglomerular cells. At this point, the tubular epithelium is modified histologically to form the macula densa. The juxtaglomerular cells, the macula densa and the lacis cells (specialized glandular cells present at the vascular angle formed by the afferent and efferent arterioles whose significance at this location is unknown) are collectively known as the juxtaglomerular apparatus (JGA). Juxtaglomerular cells are the site of renin synthesis and secretion and thus play a critical role in renin-angiotensin system.

Renal tubule

- Attached to each Bowman's capsule is a long, thin tubule with three distinct regions- proximal convoluted tubule (PCT), loop of Henie and distal convoluted tubule (DCT).

Proximal convoluted tubule

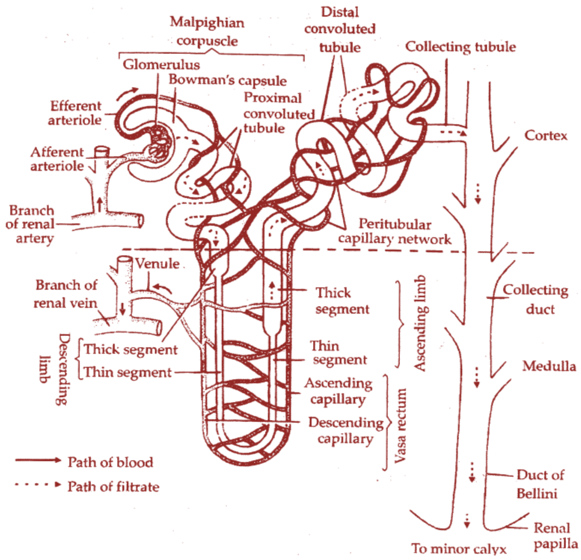
- The first region of the renal tubule is called the proximal convoluted tubule. 'Proximal' means that it is near Bowman's capsule, and 'convoluted' describes its coiled and looped shape. It is about 14 mm long and lined by a single layer of cuboidal epithelial cells. Cells of the proximal convoluted tubule have numerous brush bordered microvilli which increase surface area and mitochondria which provide energy for reabsorption of salts by active transport.

Loop of Henie

- The proximal convoluted tubule leads to the second region, the loop of Henie. It is a U-shaped or hair pin tube that dips deeply into the medulla within a renal pyramid and then loops back towards the cortex. Its primary role is to concentrate the salt in the interstitium; the tissue surrounding the loop.
- The loop of Henie consists of a descending limb and an ascending limb. These limbs have different properties and play different roles in urine formation.
- Descending limb of loop of Henie is relatively thin and long. It is freely permeable to water and is lined with squamous epithelial cells however, cells possess sparse micro-villi arid hence less mitochondria. Ascending limb of loop of Henie is comparatively thicker and is composed of flattened cuboidal epithelium. It is impermeable to water but permeable to K^+, Cl^- and Na^+.

Distal convoluted tubule

- The third region of the renal tubule is the distal convoluted tubule. 'Distal' means that it is farther from Bowman's capsule than the other regions. It is lined by cuboidal cells that have few, small and irregularly spaced microvilli (no brush border). The terminal part of the distal convoluted tubule is straight and is called the junctional tubule (= connecting tubule).
- Distal convoluted tubule continues into a short straight collecting tubule. It is also present in renal cortex. It is lined by ciliated cuboidal epithelium. Collecting tubules of many nephrons open into a large collecting duct which passes downwards from cortex to the medulla region and further join to form bigger ducts of Bellini. The ducts of Bellini opens into renal pelvis.
- The collecting duct has important functions in regulating the composition of urine, as water, ions, and nutrients are reabsorbed from the filtrate in the nephron tubules and collecting ducts. This reabsorption prevents the loss of useful nutrients, ions, and water, and provides an opportunity for tubule cells to regulate the composition of blood and the body fluids.



NEPHRON'S BLOOD SUPPLY

- There is an intimate association between the blood vessels and the nephrons of the kidney. This association permits both extensive filtration from the blood and selective reabsorption back into the blood.
- After entering each kidney, the renal artery branches repeatedly, forming smaller and smaller arteries, until tiny arterioles reach each of the 1 million nephrons. An afferent arteriole delivers blood to the glomerulus for filtration, an efferent arterioles drains filtered blood away from the same glomerulus.
- The efferent arteriole connects to a second network of capillaries, the peritubular capillaries, which are closely associated with the nephron tubule. It is into these peritubular capillaries that water, ions and nutrients are reabsorbed from the filtrate in the nephron tubule. From the peritubular capillary network arise the capillaries of vasa recta, which extend parallel to the loops of Henie and the collecting ducts in the medulla. The vasa recta consist of descending capillaries and ascending capillaries. All the capillary networks join to form renal venules which join to form a renal vein that opens into the inferior vena cava.

CHEMOAUTOTROPHIC NUTRITION

- Some bacteria which lack the chlorophyll pigments and do not utilize light as a source of energy during the synthesis of food, utilize the energy obtained in the form of ATP from the oxidation of inorganic chemical substances such as ammonia, nitrites, hydrogen sulphide and ferrous iron, etc. with molecular oxygen.

- Some of the common examples of chemoautotrophic bacteria are as follows :
  - Sulphur bacteria, e.g., Beggiatoa, Thiothrix and Thiobacillus thiooxidans, etc.
  - Iron bacteria

DIGESTION OF FATS

- Fats and oils of the ingested food are triglycerides. They are digested by Upases. Their digestion starts in the stomach and is nearly completed in the small intestine. .

(I) Saliva

- It contains almost no lipase, nor any fatemulsifying agent occurs in the oral cavity.

(II) Stomach

- Stomach also lacks fat-emulsifying agent. However, gastric juice contains gastric lipase, which converts some fats into monoglycerides and fatty acids. The reaction is negligible as the enzyme is sensitive to free acid and is soon destroyed by HCl.

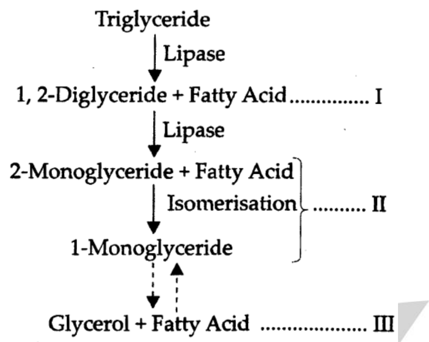
(III) Small intestine

- In the small intestine, food meets with three secretions: bile, pancreatic juice and intestinal juice, all alkaline in nature.
- **Bile** - It contains no enzyme, and, thus, has no chemical action on food. Its salts, namely, sodium glycocholate and sodium taurocholate, reduce the surface tension of large fat droplets and break them into many small ones. The process is called emulsification, as it produces a fine emulsion of fats in the aqueous intestinal contents. The small fat droplets present larger surface area to lipase. This increases lipase action on fats.

  Triglycerides $\xrightarrow{\text{Bile Salts}}$ Emulsified Triglycerides
- **Pancreatic juice** - It contains pancreatic lipase, which is the principal fat- digesting enzyme.

  It hydrolyses fats in 3 stages.

  - In the first stage (I), lipase separates one fatty acid molecule, changing the emulsified triglyceride into a diglyceride.
  - In the second stage (II), the diglyceride is broken down into another fatty acid molecule and a monoglyceride.
  - In the third stage (III), the monoglyceride is hydrolyzed to another fatty acid molecule and a glycerol molecule.
- Thus, a complete hydrolysis of a fat molecule gives three fatty acid molecules and one glycerol molecule. However, normally the digestion of fats remains incomplete in the intestine, Hydrolysis of fats is a slow process, and a few hours available for the action of lipase in the intestine are not enough for the completion of fat hydrolysis. Thus, the end products of fat hydrolysis are fatty acids, glycerol, monoglycerides, diglycerides and even triglycerides.
- Lipase is activated by the bile.



Schematic representation of digestion of triglycerides.

- **Intestinal juice** - Intestinal glands secrete intestinal lipase. This enzyme occurs mainly in the intestinal epithelial cells and only a small amount is released in the intestinal juice.
  - The lipase found in the intestinal juice hydrolyses some triglycerides, diglycerides and monoglycerides to fatty acids and glycerol like the pancreatic lipase.
  - The intestinal lipase present in the intestinal epithelial cells hydrolyses the absorbed triglycerides and diglycerides to monoglycerides and fatty acids.
  - Fatty acids, glycerol and monoglycerides are the end products of fat digestion.
- **Chyle** is a white or pale yellow fluid taken up by the lacteals (lymph capillaries) from the intestine during digestion. It mainly consists of absorbed fat.

CAM PATHWAY

- In succulents (members belonging to cactaceae, crurrlaceae etc.) the stomata remain closed during day time in order to reduce transpiration and the stomata open during night (scotoactive opening).
- Absorption of CO_2 during night and its storage as organic acid (malic acid) is called acidification.
- During day time malic acid undergoes oxidative decarboxylation and CO_2 is released.
- Liberation of CO_2 from an organic acid during day time is called deacidification.

- The diurnal acidification and deacidification during the night and day time respectively is called CAM (Crassulacean Acid Metabolism).
- All reactions of CAM occur in mesophyll cells.
- CAM pathway is important for the survival of succulents.

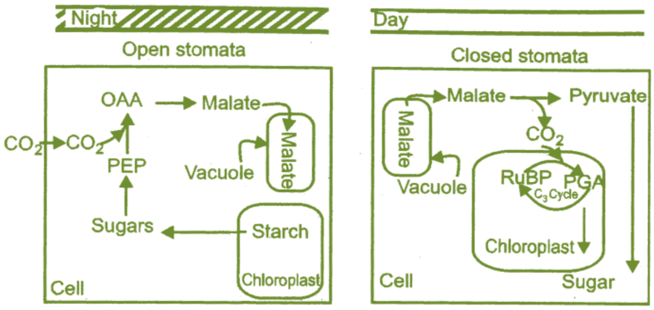


Fig.: An outline of CAM pathway.

FACTORS AFFECTING PHOTOSYNTHESIS

- The rate of photosynthetic process is affected by several external (environmental) and internal factors.
- The light reaction totally depends on the availability of light, water, pigments, etc and the dark reaction depends on temperature and available CO_2.
- Thus, all the factors are important in affecting the rate of photosynthesis.

External factors

- **Light** - In photosynthesis light is converted to chemical energy in the food -formed; It can be studied under three headings i.e., light intensity,- light quality and light duration.
  (i) Light intensity - Light intensity required to get the optimum value differs with different species. Usually with increase in light intensity, increase in rate is noticed. Clouds, fog, dust and atmospheric humidity reduce the intensity. It also affects the opening and closing of stomata thereby affecting the gaseous exchange. The value of light saturation at which further increase in photosynthetic rate is not accompanied by an increase in CO_2 uptake is called light saturation point.
  (ii) Light quality - Blue and red light of the spectrum is said to be the best light for the photosynthesis. The maximum photosynthesis is shown to occur in the red part of the spectrum with the next peak in blue part. The green light has inhibitory effect. On the other hand, plants growing in deep water absorbs green light.
  (iii) Light duration - Generally photosynthesis is independent of light duration. It is more in intermittent light than in continuous light.
- **Carbon dioxide** - Carbon dioxide is present in low concentration and forms about 0.03% of the total atmosphere. Carbon dioxide is one of the raw materials of photosynthesis. CO_2 is the natural limiting factor of photosynthesis. If the concentration of CO_2 is increased from 0.03 percent to one percent, the rate of photosynthesis increases. Concentration of CO_2 above 1 % reduces the rate of photosynthesis due to closure of stomata.
- **Water -** Water deficiency may decrease the rate as it is one of the raw materials for the process. Less availability of water may further check the rate by closing the stomata thereby affecting the entry of CO_2.
- **Temperature -** The optimum temperature for photosynthesis is 18 to 35°C. If the temperature is increased too high, the rate of photosynthesis is also reduced by time factor which is due to denaturation of enzymes involved in the process. Photosynthesis occurs in conifers at high altitudes at 35°C. Some algae in host springs can undergo photosynthesis even at 75°C. In most of the tropical plants the rate of photosynthesis increases with an increase in temperature until an optimum is reached. When other factors are not limiting, rate of photosynthesis gets doubled for every 10°C rise qf temperature until an optimum is reached.
- **Oxygen** - Excess of O_2 may become inhibitory for the process. Enhanced supply of O_2 increases the rate of respiration simultaneously decreasing the rate of photosynthesis by the common intermediate substances. The concentration of oxygen in the atmosphere is about 21% by volume and it seldom fluctuates. An increase in oxygen concentration decreases photosynthesis and the phenomenon is called Warburg effect. Oxygen may compete with CO_2 for hydrogen and may be reduced in place of CO_2.
- **Mineral elements** - Some mineral elements like Fe, Mg, Cu, Mn, Cl etc., are associated with synthesis of chlorophyll and important reactions in photosynthesis like photolysis of water.
  So absence of these elements decreases the rate of photosynthesis.

Internal factors

- **Chlorophyll** - Chlorophyll is an important internal factor for photosynthesis since it absorbs the radiant energy of light. Light initiates the mechanism of photosynthesis by transferring its electrons and getting excited. Emerson (1929) found direct relationship between the chlorophyll content and the rate of photosynthesis. The chlorophyll deficient mutants are called albinos. They can't synthesize carbohydrates by photosynthesis. So they cannot survive.
- **Leaf anatomy** - Photosynthesis also depends upon the anatomy of the leaf. If the assimilatory surface represented by palisade parenchyma is extensive there will be increased photosynthesis.
- **Leaf age** - In immature leaf the rate of photosynthesis is at minimum level. A mature leaf shows photosynthetic rate at maximum. When leaf becomes old, the rate decreases. This is due to disorganization of chloroplasts by ageing or senescence.
- **End products** - The end products of photosynthesis are carbohydrates. Accumulation of carbohydrates decreases the rate of photosynthesis. If the carbohydrates are translocated rapidly the rate of photosynthesis increases.
- **Protoplasmic factors -** These factors include the hydration of protoplasm and also the enzyme activity. If there is an appreciable decrease in the hydration of the protoplasm, the process of photosynthesis may be reduced. Above 40°C, the process of photosynthesis is inhibited because the enzymes get denatured.