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Life Processes

ON BEING ALIVE

An animal is alive if it shows visible movement, like running, walking, moving different body parts and breathing. A plant is alive if it is green in colour, shows visible growth over a period of time. However, using visible movements as the defining characteristic of life is not enough. Even molecular movements, which are invisible to the naked eye, are necessary for life. Viruses are an exception which lack molecular movements outside the host cell. Because of which there is a controversy about whether they are alive or not. Molecular movements are required for repairing and maintaining the different structures in the organisms, the organized nature of which breaks down because of the effects of environment.

The maintenance of functions of living organisms must go on even when they are not doing anything in particular. The basic functions performed by living organisms to maintain their life on this earth are called life processes.

Energy is needed for these maintenance processes. The process by which a source of energy which we call food is transferred from outside the body of the organism to the inside is called nutrition. Additional raw material in the form of food is also required when the body size of the organism grows. Different organisms can use different kinds of nutritional processes. The outside sources of energy that is food is also varied because of the different environmental conditions.

These sources of energy need to be broken down or built to finally convert it to a uniform source of energy that can be used for various metabolic processes. Most common chemical means for breakdown of molecules is the oxidizing - reducing reactions for which oxygen is sourced by the organisms from outside the body. This process by which

oxygen is obtained from outside the body and is used breakdown of food sources for cellular needs is called respiration.

In multicellular organisms, various organs and groups of tissues are specialized to perform various functions. Therefore, food and oxygen is taken up by a particular organ system or specialized tissues but is required by all the cells in the organism. This results in the transportation system.

In addition, various metabolic functions results in creation of by products some of which can be harmful to the organism. The removal of these products is by a process called excretion.

WHAT IS NUTRITION?

It is a process of intake of nutrients and their utilization by the body to release energy. During the process, nutrients are converted into simple absorbable forms.

Nutrient

The substances which an organism obtains from its surroundings and uses them either as an energy source, or for the biosynthesis of body constituents are called nutrients.

MODES OF NUTRITION

There are mainly two modes of nutrition :

1. Autotrophic Mode of Nutrition: The word 'auto' means 'self' and 'trophe' means 'nutrition'. Autotrophic nutrition is that mode of nutrition in which an organism synthesizes its own food from the simple inorganic materials like carbon dioxide and water present in the surroundings (with the help of sunlight energy).

The green plants have an autotrophic mode of nutrition. Some bacteria also obtain their food by the autotrophic mode of nutrition. These organisms which can make their own food from carbon dioxide and water are called *autotrophs*.

2. Heterotrophic Mode of Nutrition: Heterotrophic nutrition is that mode of nutrition in which an organism cannot make (or synthesize) its own food from simple inorganic materials like carbon dioxide and water, and depends on other organisms for its food. All

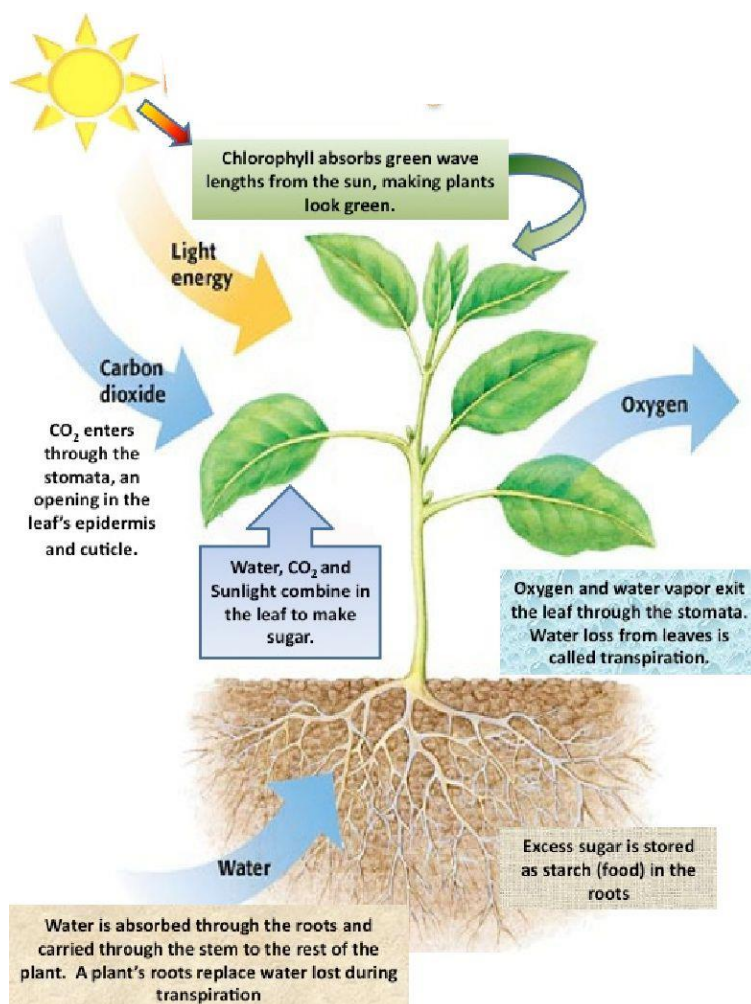
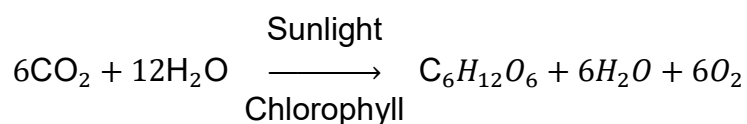
fungi, non-green plants, animals and most bacteria also have heterotrophic mode of nutrition.

AUTOTROPHIC NUTRITION IN PLANTS/PHOTOSYNTHESIS

The plants use the energy in sunlight to prepare food from carbon dioxide and water in the presence of chlorophyll. Chlorophyll is present in 'chloroplasts' inside the plant cells. The process of photosynthesis takes place in the parts of the plant.

Photosynthesis is the only natural process in which oxygen is liberated into the atmosphere. Oxygen liberated during photosynthesis comes from water by the process of photolysis (Breakdown in the presence of light).

The chemical reaction for this is :



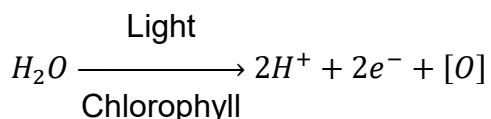
Glucose is stored in the form of starch in plants.

Raw Materials for Photosynthesis

CO₂ and water are the raw materials used in photosynthesis.

a) CO₂ : Carbon dioxide gas enters the leaves of the plant through the stomata. Stomata are minute pores embedded in the epidermis of plants. Stomata are surrounded by guard cells. Guard cells are bean shaped in dicots and dumbel-shaped in monocots. The epidermal cells surrounding the guard cells are called subsidiary cells or accessory cells.

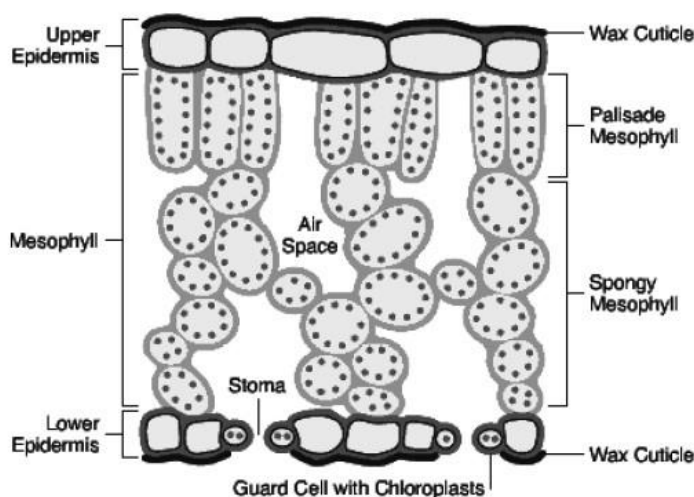
b) Water: During the light phase of photosynthesis, splitting of water molecule (also known as *photolysis*) takes place as follows :



Arnon used the word assimilation power for ATP + NADPH produced at the end of the light reaction. Arnon also coined the terms cyclic and non-cyclic photophosphorylation. The point at which the rate of photosynthesis and respiration within the plant are exactly balanced, and one process uses up the products of the other process is called compensation point. Compensation point can be reached in the morning or evening hours.

Site of photosynthesis - Chloroplasts

In a cross-section of a leaf, chloroplasts are seen as disc-like organelles in the photosynthetic cells of the leaf mesophyll cells which includes palisade tissue below the upper epidermis and spongy mesophyll towards lower epidermis.



Cross-section of leaf showing chloroplast

Trapping of Solar Energy by Sunlight

Chlorophyll is a green pigment. The green colour of the plants is due to the presence of chlorophyll in them. Chlorophyll traps the sunlight energy and converts it into chemical energy during the process of photosynthesis. There are many different types of chlorophyll molecules, which are named as chlorophyll a, b, c, d, e and bacteriochlorophyll. Out of these, chlorophyll a, and chlorophyll b are the most abundant and most common chlorophyll types found in all the plants.

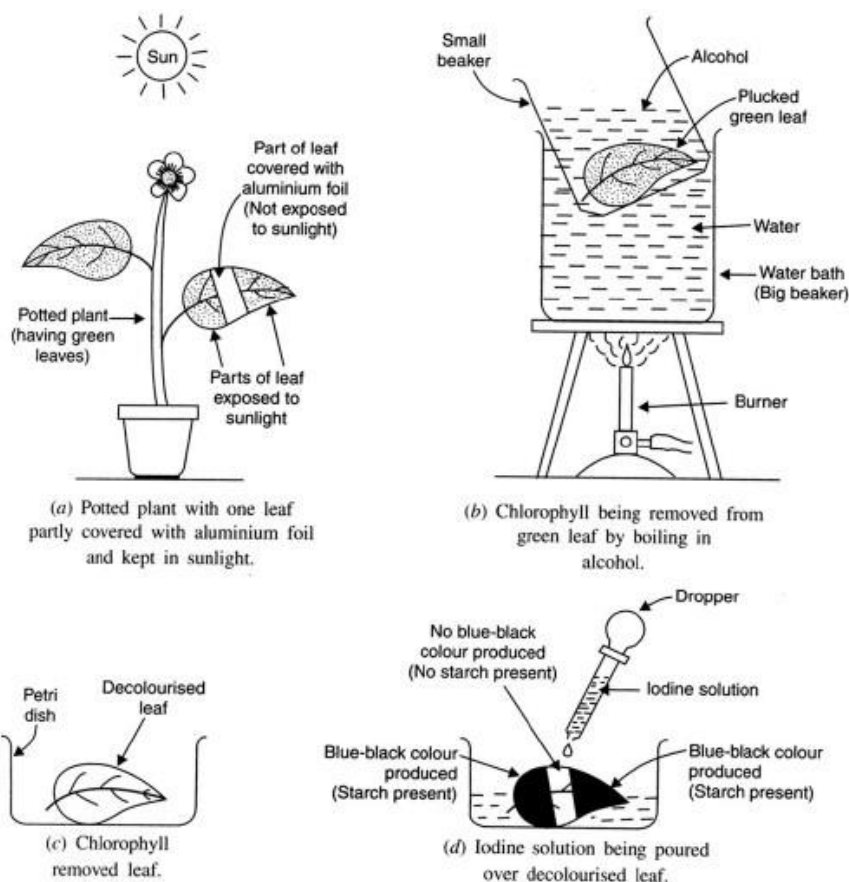
The photosynthetically active radiation (PAR) lies in the range of 400 nm to 700 nm. Chlorophyll absorbs mainly blue-violet light and red-orange of visible light.

Another type of pigments which are present in plants and help chlorophyll do its job are carotenoids. The carotenoids are yellow, orange, red or brown pigments which absorb sunlight. The role of carotenoid pigments is to absorb sunlight energy and pass it on to chlorophyll for the purpose of photosynthesis. The carotenoids themselves do not carry out the process of photosynthesis. They only help chlorophyll. We usually do not see the colours of carotenoid pigments in the plants because their colour is masked by the large amount of green colour of chlorophyll.

1. Experiment to show that sunlight is necessary for photosynthesis

We take a potted plant having green leaves.

Take a thin strip of aluminium foil and wrap it in the centre of one leaf on both the sides (while the leaf is still attached to the plant). Keep this potted plant in bright sunshine for three to four days. Pluck the partially covered leaf from the plant and remove its aluminium foil. Chlorophyll of plucked leaf is removed by boiling it in alcohol. Remove the colourless leaf from alcohol and wash it thoroughly with water to remove any chlorophyll which may be sticking to it. Place the colourless leaf in a petri-dish. Drop iodine solution over the decolourised leaf with the help of a dropper. Middle part of leaf which was covered with aluminium foil does not turn blue-black. The uncovered part of leaf which was exposed to sunlight turns blue-black showing that starch is present in this part of leaf.

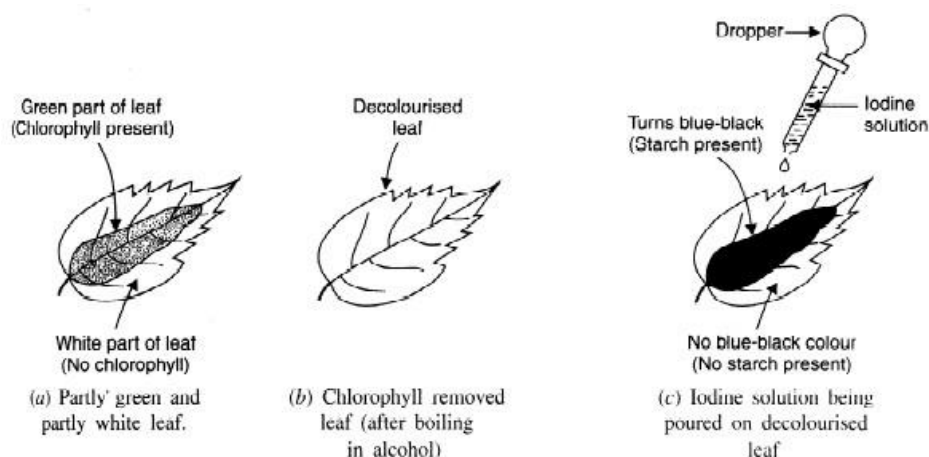


Experiment to show that sunlight is necessary for photosynthesis

2. Experiment to show that chlorophyll is necessary for photosynthesis

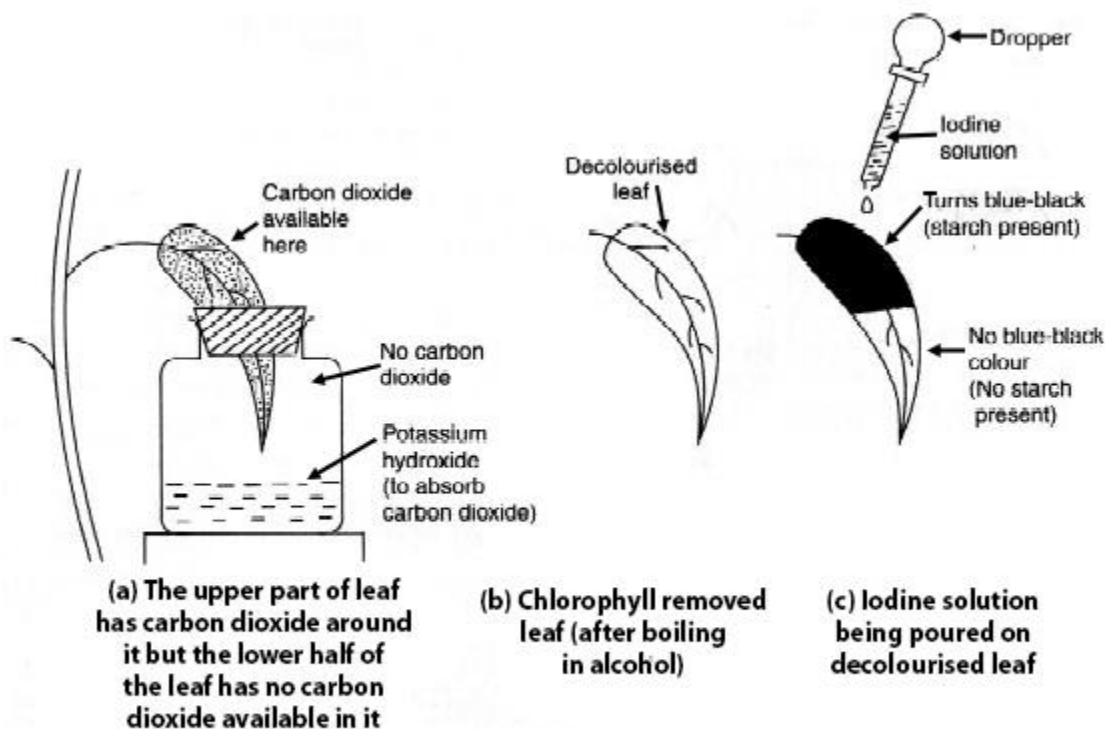
We take a potted plant like Croton whose leaves are partly white. The green part of the leaf has chlorophyll but the white part of the leaf does not have chlorophyll. Place this plant in a completely dark place for about three days to destarch its leaves. Take out the potted plant from the dark place and keep it in bright sunshine for three to four days.

Pluck the variegated leaf from the plant and remove its green colour 'chlorophyll' by boiling it in alcohol. Wash the decolourised leaf with water. Pour iodine solution over the colourless leaf. You will find that the outer part of leaf that was originally white does not turn blue-black on adding iodine solution showing that no starch is present in this outer part of the leaf. The inner part of leaf which was originally green (contained chlorophyll) turns blue-black on adding iodine solution showing that starch is present in this inner part of the leaf. Therefore, chlorophyll is necessary for the process of photosynthesis to take place.



Experiment to show that chlorophyll is necessary for photosynthesis

3. Experiment to show that CO_2 is necessary for photosynthesis / Half leaf / Mole's experiment



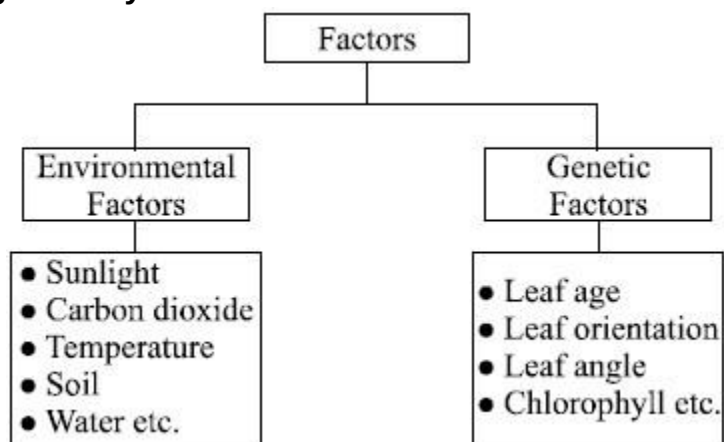
Experiment to show that CO_2 is necessary for photosynthesis

We take a potted plant having long and narrow leaves and place it in a completely dark place for about three days to destarch its leaves. Take glass bottle having a wide mouth and put some potassium hydroxide solution in it. Take a rubber cork which fits tightly into the mouth of the glass bottle and cut it into two halves.

Put a destarched leaf of the potted plant (while it is still attached to the plant), in between the two halves of the cut cork and then fit the cork in the mouth of the glass bottle. The upper half of the leaf should remain outside the glass bottle and only the lower half of the leaf should be inside the glass bottle. This potted plant is kept in sunlight for 3 to 4 days. Pluck the leaf from the plant and take it out from the glass bottle. Remove the green coloured chlorophyll from the leaf by boiling it in alcohol. Wash the decolourised leaf with water. Pour iodine solution over the colourless leaf.

We will find that the lower half of the leaf (which was inside the glass bottle having no carbon dioxide around it), does not turn blue-black on adding iodine solution, showing that no starch is present in this lower half of the leaf. From this observation we conclude that the photosynthesis to make starch in the leaf does not take place without carbon dioxide.

Factors Affecting Photosynthesis



Sunlight: Both quality and intensity of light influences photosynthesis. Light between the wavelength of 400 nm and 700 nm is most effective for photosynthesis. Maximum photosynthesis occurs in the red region of the light spectrum.

Carbon dioxide: CO₂ concentration of the atmosphere is about 0.036% or 360 ppm. Increase in CO₂ concentration increases the rate of photosynthesis initially.

Temperature: Temperature does not influence light reaction of photosynthesis but affects the enzyme controlled dark reactions.

Water (Soil water): Water supplies H^+ and electrons for CO_2 fixation. Abundant water supply allows an increased photosynthetic rate.

Chlorophyll: Photosynthesis does not occur in the absence of chlorophyll.

Bacterial Photosynthesis

Certain bacteria are also capable of photosynthesizing like the green plants. The only difference in the bacterial photosynthesis is that substances other than water act as hydrogen 'donors'. Liberation of oxygen does not occur in such cases.

The green sulphur bacteria have a pigment '*bacteriovirdin*' similar to chlorophyll. These bacteria grow in hydrogen sulphide medium which acts as source of hydrogen.

The purple sulphur bacteria have the pigment bacteriochlorophyll. These bacteria can utilise a number of sulphur compounds and also molecular hydrogen. In the absence of inorganic sulphur compounds, they can live heterotrophically on organic carbon compounds.

Chemosynthesis

There are a number of aerobic bacteria, which carry on assimilation of CO_2 without the help of radiant energy. They obtain the energy required for synthesis by carrying out oxidation of certain inorganic compounds. The common examples are nitrifying bacteria, *Nitrosomonas* and *Nitrobacter* which oxidise ammonia to nitrite and nitrite to nitrate respectively, the pigmented sulphur bacteria such as *Beggiatoa*, which oxidise hydrogen sulphide to sulphur, the iron bacteria which oxidise ferrous hydroxide to ferric hydroxide and hydrogen.

Types of Heterotrophic Nutrition

The heterotrophic mode of nutrition in plants is of two types :

1. Saprotrophic nutrition
2. Parasitic nutrition

1. Saprotrophic nutrition (sapro = rotten; trophe = nutrition)

It is the type of nutrition in which organisms obtain their food from dead organic matter by decomposing it.

Examples: Fungi like moulds, mushrooms, yeast etc. and many bacteria.

Saprophytes carry out 'external digestion' by secreting enzymes like cellulases, chitinases, amylases and proteinases and then absorbing the food in the soluble form.

Saprophytic organisms are natural scavengers and they break down the dead bodies of plants and animals, enabling the recycling of the components.

2. Parasitic nutrition in plants

It is the kind of nutrition in which an organism derives its food from another living organism (called its host). A parasite receives its food from the host but gives no benefit to the host in return. A parasite usually harms the host, the host may be a plant or animal. Parasites may be :

- (i) Obligate parasites (These parasites completely depend on their host) or
- (ii) Facultative parasites (These organisms can remain in parasitic as well as independent mode of life).

Parasitic plants are of two types :

i) Total / holo / obligate parasites / complete parasites – They are non-green, penetrate the host plant with the help of haustoria to suck the prepared food. Examples are :

- *Cuscuta* (Total stem parasite)
- *Orobanche* and *Rafflesia* (Total root parasitise)

ii) Partial Parasites : These are green in colour and can do photosynthesis but they depend on their host for their requirement of water and minerals. Examples are :

- *Viscum* (partial stem parasite) and
- *Santalum* (partial root parasite).

Other Mode of Nutrition which are found in some plants

1. *Symbiosis*: It is a type of association between two organisms in which both the partners are benefited.

- **Lichens**: It is an association between algae and fungi. The fungal component obtains nutrition from the autotrophic alga and the fungi absorbs water and minerals that its supply to the alga. It also provides protection to the algal partner.

- **Nodulation:** The bacterium *Rhizobium* forms nodules in the roots of leguminous plants. Bacteria fix atmospheric nitrogen and supply the same to the host plant. The plant provides nutrition to the bacterium.
- **Mycorrhiza:** It is an association between fungal species and roots of higher plants, i.e., gymnosperms and angiosperms. The fungi gets food from the higher plant and the fungi in return increases the rate of absorption of water and minerals like phosphorus, potassium, calcium, etc. It can be of two types:

2. *Insectivorous Plants:* They are green and otherwise autotrophic plants which behave like heterotrophic organisms for supplementing their nitrogen supply through catching and digesting small animals like insects, e.g., *Nepenthes*, *Sarracenia*, *Drosera*, *Dionaea*, *Utricularia*.

NUTRITION IN ANIMALS

Plants are autotrophic organisms which can manufacture their own food. But this is not so in the case of animals. Animals are heterotrophs and hence they depend on other organisms for their food.

Holozoic Nutrition

The holozoic nutrition is that nutrition in which an organism takes the complex organic food materials into its body by the process of ingestion, the ingested food is digested and then absorbed into the body cells of the organism.

The undigested and unabsorbed part of the food is then thrown out of the body of the organism by the process of egestion. The human beings and most of the animals have a holozoic mode of nutrition.

Animals obtain their Food from Plants or Other Animals

Since animals cannot make their own food, they depend on other sources for food. This readymade food comes either from 'plants' or 'other animals'.

Many other animals obtain their food by eating the flesh of other animals. For example, fish, birds, snakes and insects. All obtain their food from other animals. The big fish eats small fish; the birds eat worms and insects; the snake eats frogs and the insects eat dead bodies of animals.

All the animals can be divided into three groups on the basis of their food habits (or eating habits). These are:

- Herbivores
- Carnivores
- Omnivores

(i) **Herbivores:** Some animals eat only plants (or their products). Those animals which eat only plants are called *herbivores*. The herbivores may eat grasses, leaves, grains, fruits or the bark of trees. Some of the examples of herbivores are : goat, cow, buffalo, sheep, horse, deer, camel, etc.

(ii) **Carnivores:** Some animals eat only other animals. They do not eat plant food at all. Those animals which eat only the meat (or flesh) of other animals are called *carnivores*. Some examples are : lion, tiger, frog. etc.

(iii) **Omnivores:** Some animals eat both, plants as well as other animals as food. Those animals are called *omnivores*. Thus, omnivores are plant eaters as well as meat eaters.

Different Steps in the Process of Nutrition

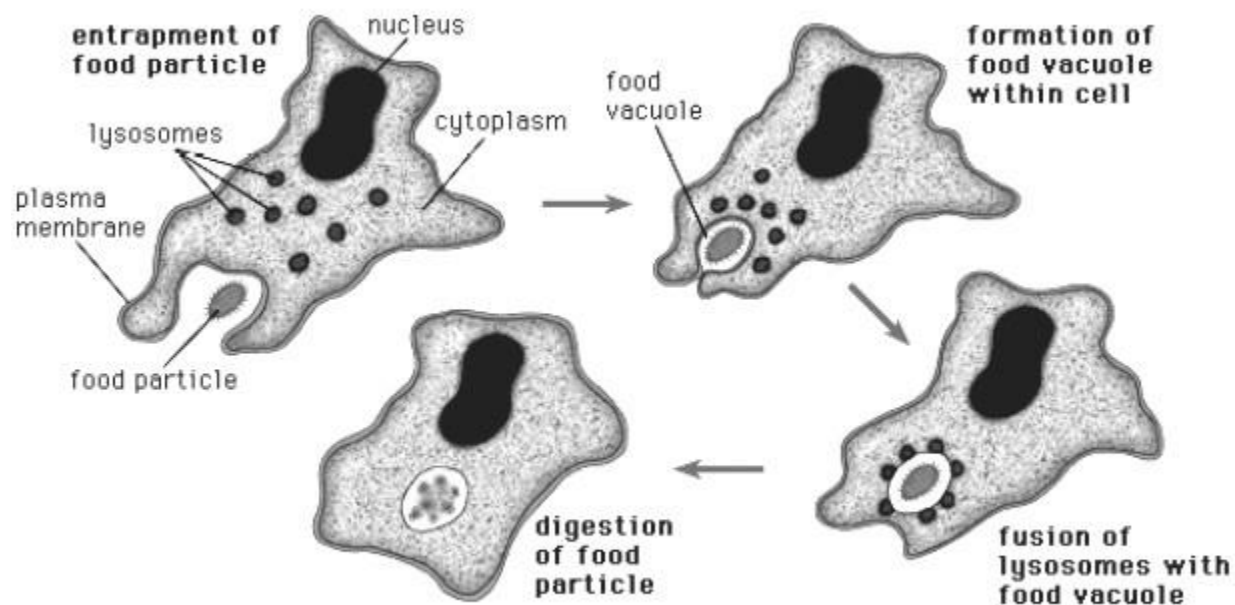
There are five steps in the process of nutrition in animals. These are: Ingestion, Digestion, Absorption, Assimilation and Egestion. All these steps are discussed below:

- **Ingestion:** The process of taking food into the body is called ingestion. In most simple terms, ingestion means 'eating of food' by the animal.
- **Digestion:** The process in which the food containing large, insoluble molecules is broken down into small, water soluble molecules (which can be absorbed by the body) is called digestion.
- **Absorption:** After digestion, the food molecules become small and soluble. The soluble food molecules can pass through the walls of our intestine and go into blood. The process in which the digested food passes through intestinal wall into blood stream is called absorption.

- **Assimilation:** Blood carries the absorbed food to all the parts of the body. The food then enters each and every cell of the body where it is used for producing energy and for making materials for the growth and repair of the body. The process in which the absorbed food is taken in by body cells and used for energy, growth and repair is called assimilation.
- **Egestion:** A part of the food which we eat remains undigested (or insoluble) which cannot be used by the body. This undigested part of the food is then removed from the body in the form of faeces. The process in which the undigested food is removed from the body is called egestion.

Nutrition in Unicellular Organisms

1. **Amoeba:** *Amoeba* is a unicellular animal. *Amoeba* eats tiny (microscopic) plants and animals as 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 ('Phagocytosis' means 'cell feeding'). The various steps involved in the nutrition of *Amoeba* are : ingestion, digestion, absorption, assimilation and egestion.



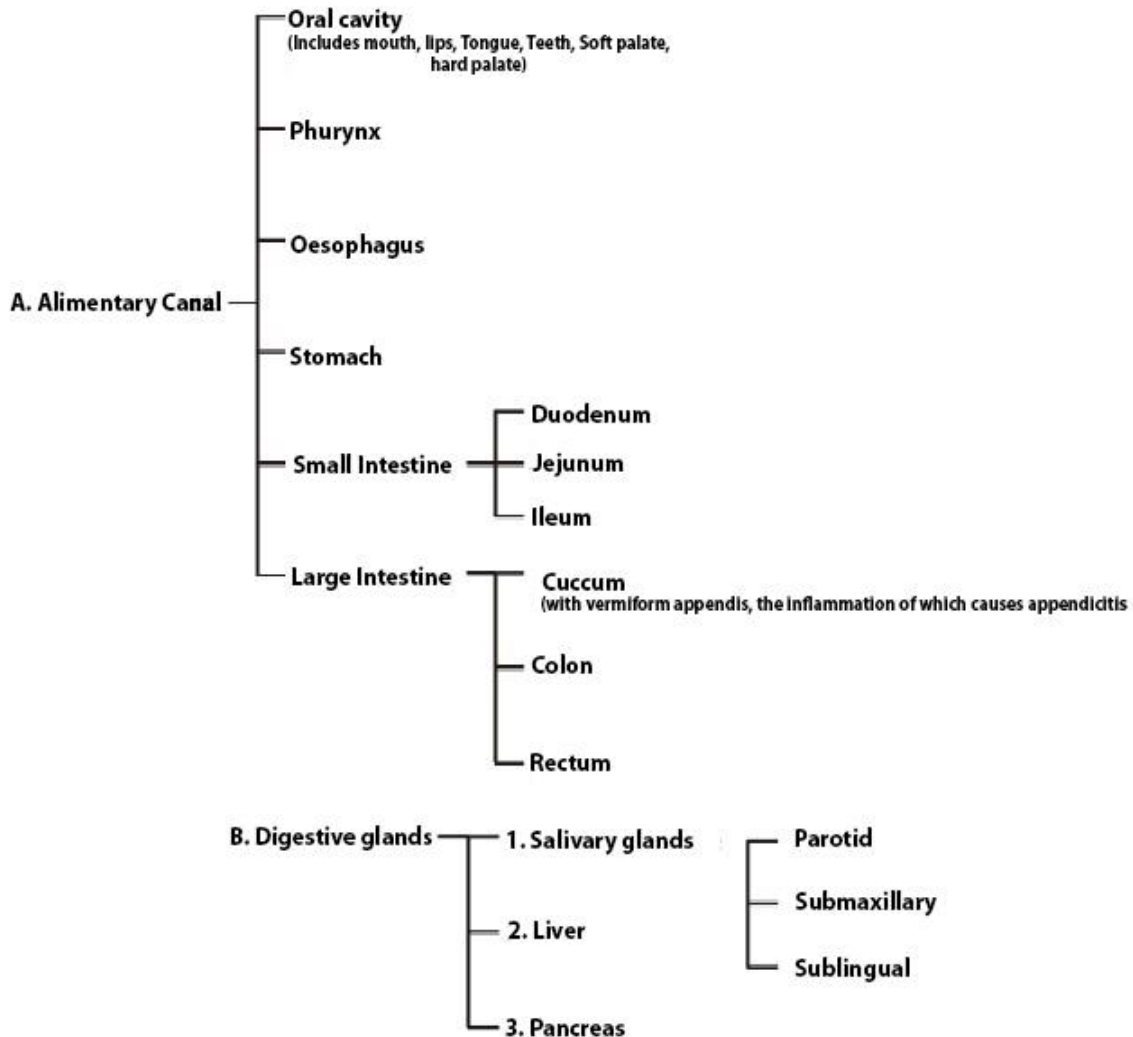
Different stages showing the nutrition (feeding) in Amoeba

- **Ingestion:** *Amoeba* has no mouth or a fixed place for the ingestion of food (intake of food). *Amoeba* ingests food by using its pseudopodia. When a food particle comes near *Amoeba*, the *Amoeba* ingests this food particle by forming pseudopodia around it.
- **Digestion:** In *Amoeba*, food is digested in the food vacuole by digestive enzymes. The enzymes from surrounding cytoplasm enter into the food vacuole and break down the food into small and soluble molecules by chemical reactions.
- **Absorption:** The digested food present in the food vacuole of *Amoeba* is absorbed directly into the cytoplasm of *Amoeba* cell by diffusion. Since *Amoeba* consists of only one small cell, it does not require blood system to carry the digested food.
- **Assimilation:** A part of food absorbed in *Amoeba* cell is used to obtain energy through respiration. The remaining part of absorbed food is used to make the parts of *Amoeba* cell which lead to the growth of *Amoeba*.
- **Egestion:** *Amoeba* has no fixed place (like anus) for removing the undigested part of food. When a considerable amount of undigested food collects inside food vacuole in *Amoeba*, then it comes to the cell surface, fuses with plasma membrane and suddenly ruptures at any place, and the undigested food is thrown out of the body of *Amoeba*.

2. **Paramecium:** In *paramecium*, which is also a unicellular organism, the cell has a definite shape and food is taken in at a specific spot. Food is moved to this spot by the movement of cilia which cover the entire surface of the cell.

NUTRITION IN HUMAN BEINGS

In human beings, the organs which are responsible for ingestion, digestion, absorption, assimilation and egestion together constitute digestive system. The digestive system consists of alimentary canal and digestive glands.



A. Alimentary Canal

The alimentary canal is a long hollow tube which runs from the mouth to the anus. Together with several other organs and glands, including the liver and the pancreas, it makes up the digestive system.

The total length of the human alimentary canal is between 5 and 6 m, from mouth to anus. To fit this considerable length into body, parts of the canal are folded and coiled inside the abdomen.

The mucus is a substance secreted along the tube by cells lining its walls. Mucus helps food to slide through the canal without doing too much damage to the lining. It also forms a protective covering which keeps the digestive juices, which are inside the lumen of the

canal, from coming into contact with the living cells of the walls. Along the whole length of the alimentary canal there are muscles in the walls. These produce waves of contraction and relaxation called peristaltic waves, which move food along the alimentary canal and help to mix the contents. Each region of the alimentary canal has its own function and different structure.

The different parts of the alimentary canal and their functions are as follows:

1. Mouth

Taking food into the mouth is called ingestion. We use lips, tongue and teeth. The tongue is also important in tasting food; to tell you whether it is good to eat; if not it will be ejected from the mouth rather than swallowed.

The main purpose of the human teeth is to break up large pieces of food, thus beginning the process of the mechanical digestion. This is done by chewing, or *mastication*. Strong muscle in the jaws move the lower jaw up and down from side to side, grinding the teeth in the lower jaw against those in the upper jaw.

The premolar and molar teeth have ridges and grooves, which trap food between them and crush it as chew. Mastication greatly increases the surface area of the food, bringing more of it into direct contact with enzymes in the digestive juice and so speeding up chemical digestion.

Three pairs of salivary glands secrete watery liquid saliva, which pours along ducts into the mouth. Like all secretions along the alimentary canal, saliva is mostly water. It contains mucus, which mixes with the food as it is chewed, helping to glue it loosely together into a ball called a bolus. The mucus also makes the bolus slippery, so that is easier to swallow.

2. Stomach

When a bolus of food is swallowed, it is moved swiftly down to the esophagus by peristalsis and into stomach. The stomach is a muscular sac and produces strong, rhythmic, churning movements when there is food in the stomach. This not only mixes the food with the juices secreted in the stomach, but also helps to continue the process of mechanical breakdown begun by chewing in the mouth.

Food may be kept in the stomach for several hours. The acidic mixture of partly digested food and water, called *chyme*, cannot pass on the next part of the alimentary canal, the duodenum, until a band muscle called the *pyloric sphincter* relaxes. When this happens depends on many factors which seem to relate to how quickly the duodenum will be able to deal with what is being sent into it. For example; if there is a lot of fat chyme, it will be allowed into the duodenum only in small amounts at a time, to give the duodenum a chance to deal with it.

3. Small Intestine

The duodenum and the ileum together make up the small intestine. (The first part of the ileum is some-times known as the jejunum). The overall length of the small intestine is about 6 m, of which the duodenum makes up the first 25 cm. It is within the duodenum and the ileum that most digestion and absorption occurs.

4. Colon and Rectum

By the time the food has reached the end of the small intestine, virtually everything which could be absorbed has entered the villi. What is left? The undigested, unabsorbed remains are mostly fibre; humans cannot digest cellulose or lignin.

At the entrance of the colon from the small intestine, there is a blind-ending side branch—the caecum and appendix. The appendix has no function in humans. The colon however is very important here the remaining water is absorbed into the blood, together with sodium and chloride ions. These processes also occur in the caecum. The colon has no villi but it does have a large surface area produced by many folds in its wall, to increase the efficiency of absorption. The rectum is a short straight section of the alimentary canal, which leads from the colon to the anus and thus to the outside world. It is usually empty only receiving the contents of the colon now called faeces when they are ready to be passed out of the anus.

The control of secretions in the alimentary canal

As food passed along the alimentary canal, numerous secretions are produced to help to digest it. It is important that these secretions are only produced when needed. Various mechanisms are used to ensure that this happens.

Saliva is produced by a reflex action resulting from a stimulus of the thought, sight, smell or taste of food.

Gastric juice begin to be secreted even before anything has been eaten just at the smelling food. These impulses come from brain and along a branch of the vagus nerve to the gastric glands. In animals such as dog this impulses also cause the release of a hormone called gastrin. Like all hormones gastrin is secreted into the blood. The secretion to the pancreatic juice into the duodenum is controlled in similar way. Most secretions happen when chyme from the stomach enters in duodenum. Acid entering the duodenum causes cells in its wall secrete a hormone called secretin, which is carried in the blood to the pancreas and increases the production and release of pancreatic juice especially rich in ions.

Dental Caries

Dental caries is an infectious disease which damages the structures of teeth. Tooth decay or cavities are consequences of caries, if left untreated. The disease can lead to pain, tooth loss, infection, and, in severe cases, death of the tooth. Tooth decay is caused by certain types of acid-producing bacteria (specifically *Lactobacillus*) which cause damage in the presence of fermentable carbohydrates such as sucrose, fructose, and glucose. The resulting high levels of acidity from lactic acid in the mouth affect teeth because a tooth's special mineral content causes it to be sensitive to low pH. Specifically, a tooth (which is primarily mineral in content) is in a constant state of back- and-forth demineralization and remineralization between the 'tooth and surrounding saliva. When the pH at the surface of the tooth drops below 5.5, demineralization proceeds faster than remineralization (i.e., there is a net loss of mineral structure on the tooth's surface). This results in the decay. Depending on the extent of tooth destruction, various treatments can be used to restore teeth to proper form, function, and aesthetics, but there is no known method to regenerate large amounts of tooth structure. Instead, dental health organizations advocate preventive and prophylactic measures, such as regular oral hygiene and dietary modifications, to avoid dental caries.

B. Accessory Digestive Organs

1. **Salivary glands:** Salivary glands produce saliva which is a mixture of mucus and serous fluids, each produced to various extents in various glands. Also contains salivary amylase, (starts to break down starch) and lysozyme (antibacterial). In some mammals (and snakes) saliva may be poisonous, quietening down living prey.

They are of three types : Parotid, submandibular and sublingual. Mumps begins as infective parotitis in the parotid glands in the cheek. The submandibular and sublingual glands open into the floor of the mouth.

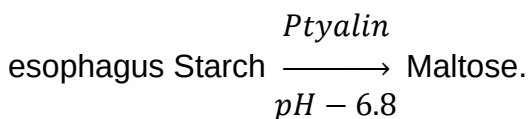
2. **Pancreas: Pancreas consists of two parts:** endocrine and exocrine gland. Exocrine part produces many enzymes which enter the duodenum via the pancreatic duct. Endocrine part produces insulin and glucagons, which are blood sugar regulators.

3. **Liver and Gall Bladder:** Bile, a watery greenish fluid is produced by the liver and secreted via the hepatic duct and cystic duct to the gall bladder for storage, and hence on demand via the common bile duct to an opening near the pancreatic duct in the duodenum. It contains bile salts, bile pigments (mainly bilirubin, essentially the non-iron part of haemoglobin) cholesterol and phospholipids. Bile salts and phospholipids emulsify fats, the rest are just being excreted. Gallstones are usually cholesterol based, may block the hepatic or common bile ducts causing pain, jaundice.

Physiology of Nutrition

- **Ingestion:** Food enters the digestive system via mouth. The lips protect its outer opening, cheeks form lateral walls, hard palate and soft palate form anterior and posterior roof.
- **Digestion:** (i) It includes mechanical and chemical breakdown of ingested food. It starts in mouth and is completed in small intestine. Food is chewed and masticated in mouth with the help of tongue, teeth (premolar and molar). Here the food is mixed with secretions of salivary glands, which contain mucus, starch-splitting enzyme called ptyalin or salivary amylase. About 30% digestion of starch takes place in mouth and the food now known as bolus enters the esophagus. This process is called

swallowing and involves coordinated activity of tongue, soft palate, pharynx and



(ii) The first phase is voluntary, food being forced into pharynx by the tongue. After this, the process is reflex. The tongue blocks the mouth, soft palate close off the nose and larynx rises, so that, the epiglottis closes off trachea. Food thus moves into pharynx and onwards by peristalsis. If we try to talk while swallowing, food may enter the respiratory passages and a cough reflex expels the bolus.

(iii) In the stomach the food is acted upon by gastric juice of stomach that contains HCl and pepsin and other enzymes. These enzymes break down proteins of food into smaller molecules which now pass onto small intestine.

(iv) In the first part of small intestine, called duodenum food (now called chyme) is acted upon by bile juice from liver and pancreatic juice from pancreas. The enzymes of pancreas and small intestine further digest carbohydrates (into glucose, fructose and galactose), proteins (into amino acids) and fats (into fat droplets or glycerides, glycerol and fatty acids) of food.

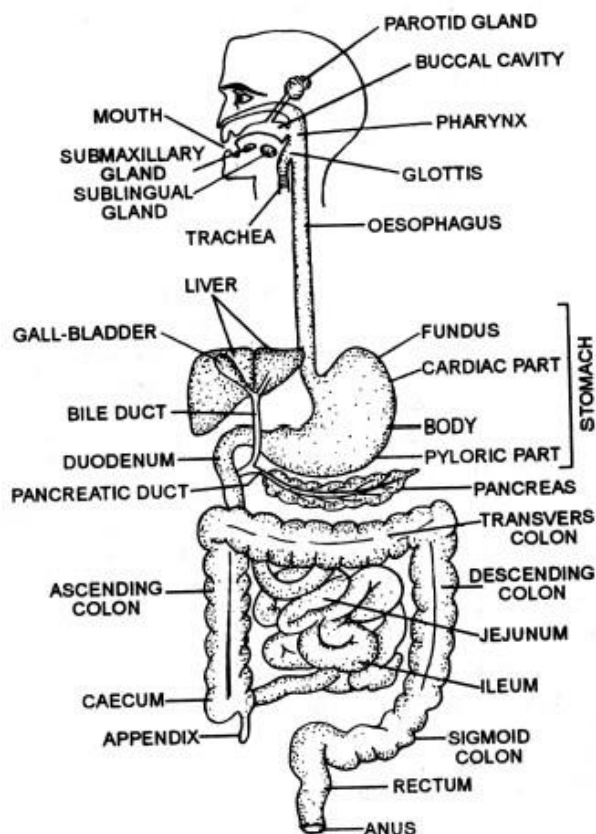
(v) The food coming from stomach is acidic and has to be made alkaline for pancreatic enzymes to act.

Bile juice from the liver accomplishes this in addition to acting on fats. Bile salts break the larger fat globules into smaller globules. The pancreas secretes pancreatic juice which contains enzymes like trypsin for digesting proteins and lipase for breaking down emulsified fats.

- **Absorption:** The digested food is ultimately absorbed by villi of cells of small intestine by simple diffusion and / or by active transport. Villi are minute finger like folds in small intestine, which increase surface area for absorption. The absorbed food is sent through blood to different parts of body.
- **Assimilation:** The absorbed food material is utilized by body in various ways. Glucose provides energy during cellular respiration and its excess amount is converted into glycogen by the enzymes of liver.

The amino acids may be used in the synthesis of a variety of structural and functional proteins and also in the synthesis of various nitrogen bases of nucleic acids. The glycerol and fatty acids either provide energy or form phospholipids for membrane formation or reconverted into fats. These fats accumulate in adipose tissues below the skin or around various organs.

- **Egestion:** The unabsorbed food is sent into large intestine where more villi absorb water from this material. The rest of material is removed from the body via the anus.



Human Digestive System

Respiration in Animals

Animals have evolved different organs for the uptake of O_2 from environment and for getting rid of CO_2 produced. Terrestrial animals can breathe O_2 in the atmosphere, but animals that live in water need to use the O_2 dissolved in water. So there are different modes of respiration in animals:

(i) Respiration through Skin: It is also called *cutaneous respiration*. It is the only mode of respiration in frog during *hibernation*. Earthworm respire through skin only. For cutaneous respiration skin is richly supplied with a network of blood capillaries and skin is kept moist by the moisture of the habitat and body secretions.

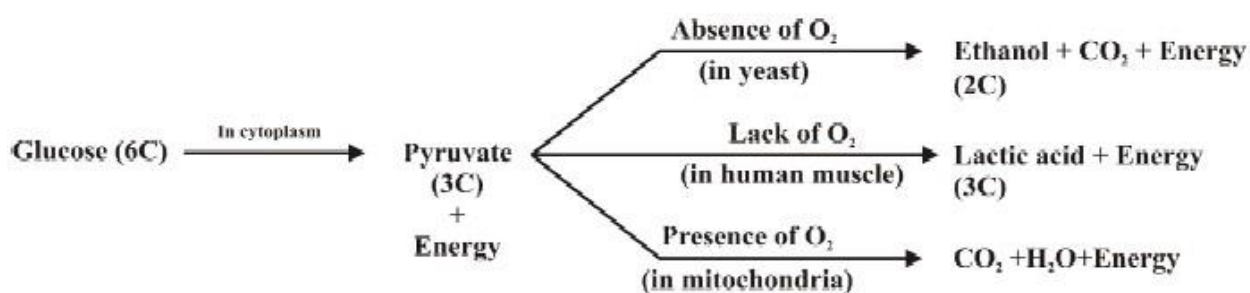
(ii) Respiration through Trachea: It is also called *tracheal respiration*. Trachea open out by *spiracles* in body wall. It is found in insects, centipedes and millipedes.

(iii) Respiration through Gills: Gills are the respiratory organs of the aquatic animals. Gills are of two types : *external* (eg. Aquatic annelids) and *internal* (e.g., fishes, prawn). It is also known as *branchial respiration*.

(iv) Respiration through lungs: It is also called *pulmonary respiration*. It is found in snails, some amphibians and in all reptiles, birds and mammals.

Types of respiration

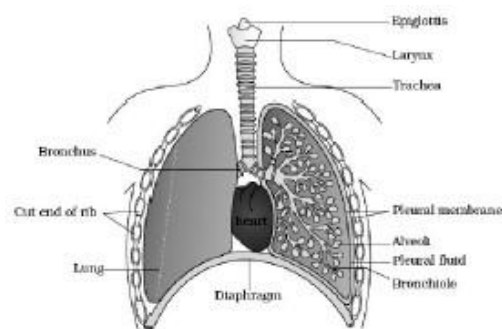
- **Aerobic Respiration:** It requires oxygen. The end products of aerobic respiration of carbohydrate are CO_2 and water.
- **Anaerobic Respiration:** It takes place in the absence of O_2 . The end products are ethyl alcohol and carbon dioxide.



Breakdown of glucose by various pathways

BREATHING IN HUMAN BEINGS

Human beings breathe through their nostrils and with the help of lungs. When we breathe, we inhale O_2 and exhale CO_2 . Respiration is achieved through mouth, nose, trachea, lungs and diaphragm. In normal breathing through nose, air travels through nasal chambers which are lined with ciliated mucus epithelium. Here it is cleared and warmed.

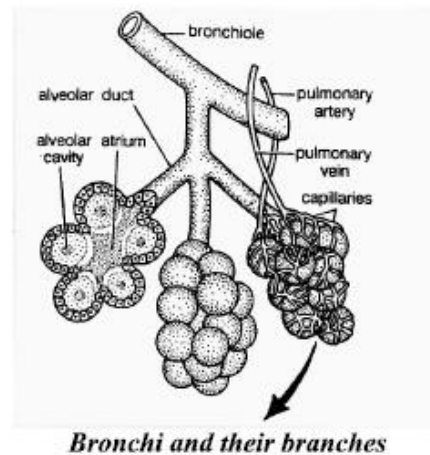


Human Respiratory System

Sensory cells detect odours. As air continues through pharynx, it crosses path of food. This is why we can breathe through mouth. The air passes the epiglottis, enters the larynx and goes down the trachea. Rings of cartilage are present in trachea, which ensure that the air-passage does not collapse.

Trachea divides into two tubes called right and left bronchi which enter the lungs.

Each bronchus then divides again forming primary bronchi, which further branch to form secondary bronchi. The secondary bronchi further divide into still smaller bronchioles, which connect to tiny air sacs called alveoli.



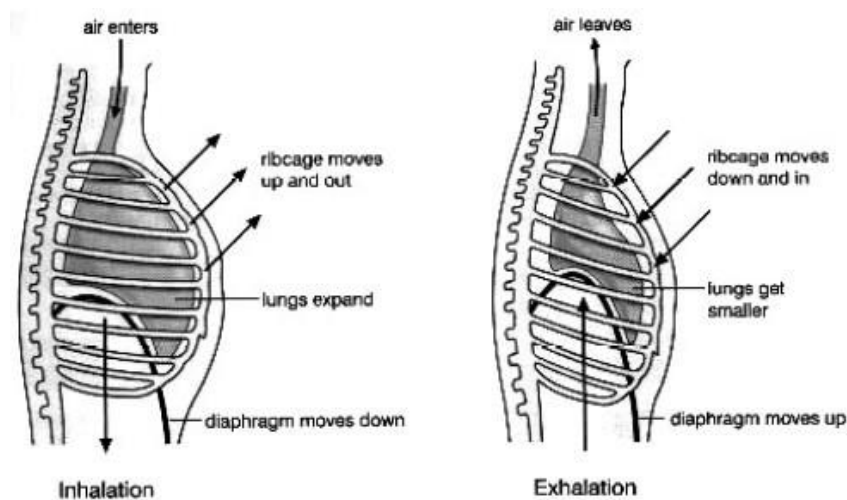
A group of alveoli appears like a cluster of grapes and gives the lungs a sponge-like texture. The alveoli are lined by a layer of moist flat epithelial cells and surrounded by network of blood capillaries. A film of lecithin (a lipid) lines the alveoli of normal lungs, it functions to lower the surface tension and enables the alveoli to remain open. The average adult's lungs contain about 600 million of these spongy, air-filled sacs that are surrounded by capillaries. The inhaled oxygen passes into the alveoli and then diffuses through the capillaries into the arterial blood. Meanwhile, the waste-rich blood from the veins releases its carbon dioxide into the alveoli. The carbon dioxide follows the same path out of the lungs when you exhale.

Breathing mechanism

Breathing has two events: **inhalation and exhalation**. During inhalation air from outside rushes into the alveoli of lungs and the thoracic cavity expands. When the volume of thoracic cavity increases the air pressure decreases inside and air from outside rushes into lungs causing the alveolar sacs to get filled with oxygen rich air. From the alveoli, oxygen diffuses into blood and is supplied to the tissue.

Breathing is an active process - requiring the contraction of skeletal muscles. The primary muscles of respiration include the external intercostal muscles (located between the ribs) and the diaphragm (a sheet of muscle located between the thoracic & abdominal cavities).

Carbon dioxide enters blood from the tissues and is carried to the alveoli of lungs for exhalation through trachea and nostrils. This process is referred to as exhalation and occurs when thoracic cavity comes back to its original size and diaphragm and rib muscles relax.



Breathing phenomenon in humans

The exchange of gases (O_2 & CO_2) between the alveoli & the blood occurs by simple diffusion: O_2 diffusing from the alveoli into the blood & CO_2 from the blood into the alveoli. Diffusion requires a concentration gradient. So, the concentration (or pressure) of O_2 in the alveoli must be kept at a higher level than in the blood & the concentration (or pressure) of CO_2 in the alveoli must be kept at a lower level than in the blood.

RESPIRATION IN PLANTS

Respiration in roots

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 extensions of the epidermal cells of a root are called root hairs. The root hairs are in contact with 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*.

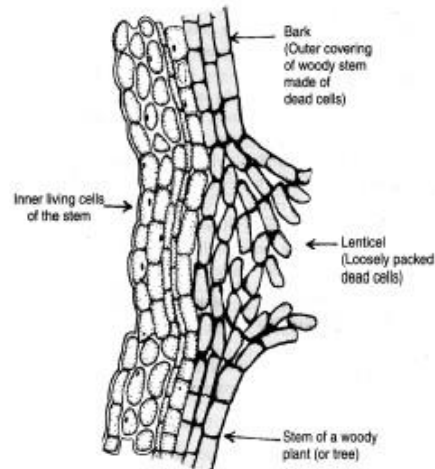
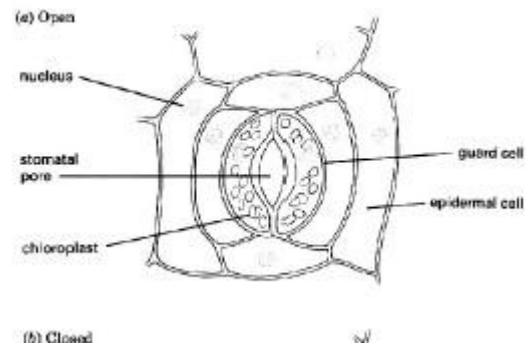


Diagram of lenticel

Lenticel

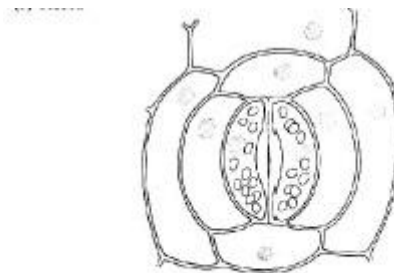
Lenticel is an area in a woody stem where the cells are loosely packed, allowing the gas exchange to take place between the air and the living cells of the stem. Lenticels are present in the hard, woody stems of large plants or trees. Some old portions of the roots also have lenticel.



(b) Closed

Stomata

Stomata are the pores (or openings) on the lower surface of the leaves of plants through which there is an exchange of gases between the air and the cells of the leaves. Water vapour from the leaves also goes out through stomata during transpiration. Please note that the soft stems of the herbaceous plants also have stomata in them.



**(a) Open stoma of a dicot leaf,
(b) Closed stoma of a dicot leaf**

Transport

A large multicellular organism has millions of cells in its body. In order to maintain its life and survive, all the cells of an organism must be supplied with essential substances like

food, oxygen, water etc. Transport is a life process in which a substance absorbed or made in one part of the body of an organism is carried to other parts of its body.

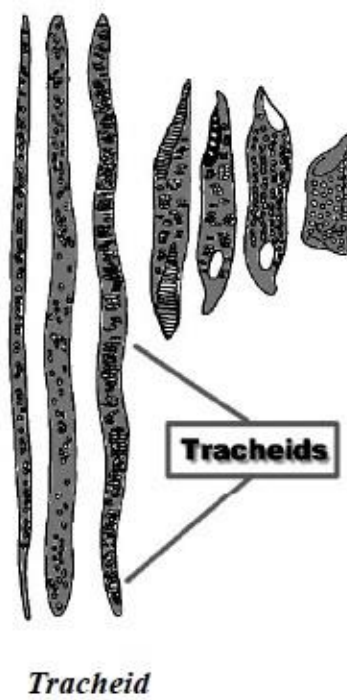
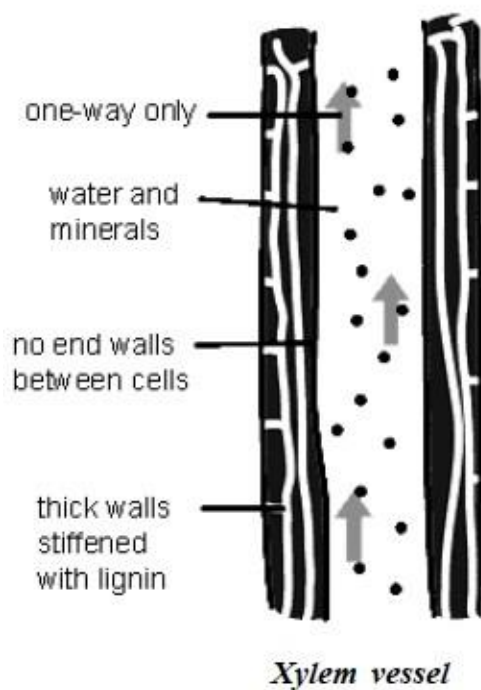
Transport in Plants

Transport of materials in a plant can be studied in two parts :

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

A. Transport of water and minerals :

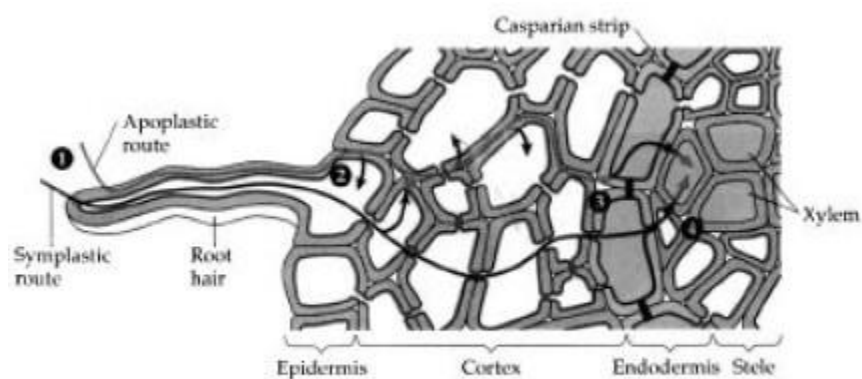
Plants require water for photosynthesis and other metabolic functions. Similarly minerals are required by plants in the synthesis of various substances water and minerals are absorbed by the roots of the plants and transported to various parts of the plants like stem, leaves and flowers. The water with dissolved minerals move through two kind of xylem tissue – xylem vessels and tracheids. These are both non living conducting tissues which have thick walls. The thickening is made of a very strong substance called lignin because of which xylem also provides strength to the plants and help to keep them upright. Both vessels and tracheid have pits which are thin areas of cell wall where no lignin has been deposited.



Vessels differ from tracheids in being wider with end walls broken down creating perforations. Tracheids are narrow, long spindle shaped cells without perforated end walls. Water passes from one tracheid to another through pits.

Xylem in angiosperms is mainly made of vessels and few tracheids whereas non flowering plants like gymnosperms and pteridophytes have only tracheids.

Vessels and tracheids of the root, stem and leaves are interconnected to form a continuous system of water conducting channels reaching all parts of the plant.



Pathway of nutrient transport in plants

The roots of a plant have root hairs. The cells of root hairs which are in contact with the soil actively takes up ions. This creates a difference in concentration of these ions between roots and the soil. Therefore, water moves into the root from the soil to eliminate this difference. There is a steady movement of water by osmosis through epidermis, root cortex, endodermis and reach the root xylem, creating a column of water that is steadily pushed upwards.

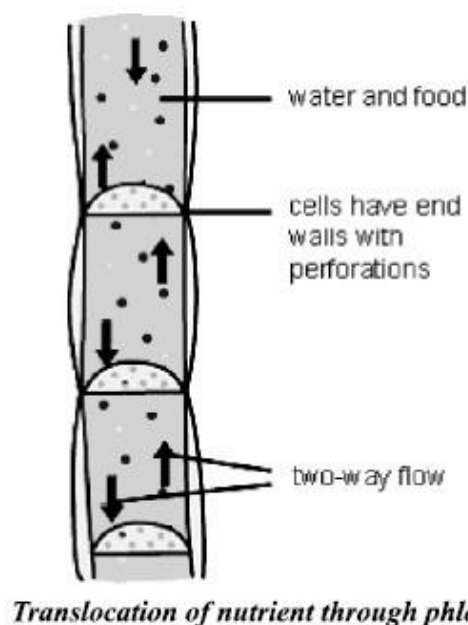
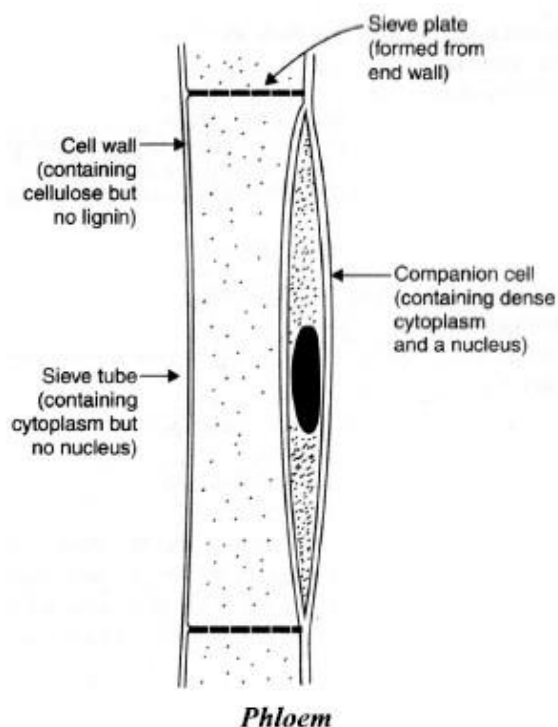
Only about 1 to 2 percent of the water absorbed by the plant is used up by the plant in photosynthesis and other metabolic activities. The rest of the water is lost by evaporation into the air through the stomata. Stomata are tiny pores present on the surface of leaves and other green parts. This evaporation of water from the leaves of a plant is called transpiration. This loss of water is made up by water from xylem vessels, which travels by osmosis. The pressure at the top of the xylem vessels in the leaves is lowered due to transpiration, whereas, pressure at the bottom of the xylem vessels remain high. This creates a kind of suction which helps in absorption and upward movement of water through xylem vessels. Movement of water and minerals in xylem is always upward.

During the night when stomata are closed the effect of root pressure in transport of water is more important.

Transport of food and other substances:

The transport of soluble products of photosynthesis is called translocation. Translocation occurs through phloem. Phloem also transports amino acids, hormones and other substances.

Phloem is made of many cells joined end to end to form sieve tubes. The end wall of sieve tubes form sieve plates. The pores in sieve plates allow the food to pass along the phloem tubes. Sieve tubes are living cells which contain cytoplasm but no nucleus. Each sieve tube cell has a companion cell adjacent to it. Many of the functions of sieve tubes are controlled by companion cells.



Unlike transport in xylem which is believed to be due to physical forces – the translocation in phloem is achieved by using energy. Food prepared during photosynthesis is transferred into phloem tissue normally in the form of sucrose using ATP. This increases the osmotic pressure of the tissue causing water to move into it. The pressure created moves the material through phloem to tissues which have less pressure. This allows the

phloem to move material according to the plants needs bidirectionally, both upwards and downwards.

Large multicellular system needs an internal plumbing system to carry materials back and forth from external world to the cells living in innermost depth of body or from one place inside body to another. As we know, the blood transports food, O_2 and waste materials in our bodies. Blood is a fluid connective tissue and consists of a fluid medium called plasma in which the cells are suspended.

Transport in Animals

The Transport system or Circulatory System is responsible for transporting materials throughout the entire body. It transports nutrients, water, and oxygen to your billions of body cells and carries away wastes such as carbon dioxide that body cells produce. It is an amazing highway that travels through your entire body connecting all your body cells.

Parts of the Circulatory System

The circulatory System is divided into three major parts:

1. Blood
2. Heart
3. Blood Vessels

1. BLOOD: Blood is a specialized body fluid (technically a tissue) that is composed of a liquid called blood plasma and blood cells suspended within the plasma.

A. PLASMA: Plasma is the straw-colored liquid in which the blood cells are suspended.

Composition of blood plasma

Component	Percent
Water	~92
Proteins	6–8
Salts	0.8
Lipids	0.6
Glucose (blood sugar)	0.1

Plasma transports materials needed by cells and materials that must be removed from cells. These include:

- various ions (Na^+ , Ca^{2+} , HCO_3^- , etc.)
- glucose and traces of other sugars
- amino acids
- other organic acids
- cholesterol and other lipids
- hormones
- urea and other wastes

B. CELLS: Suspended in the watery plasma are three types of cells.

(i) RBCs (Red Blood Cells)

(ii) WBCs (White Blood Cells)

(iii) Platelets or Thrombocytes

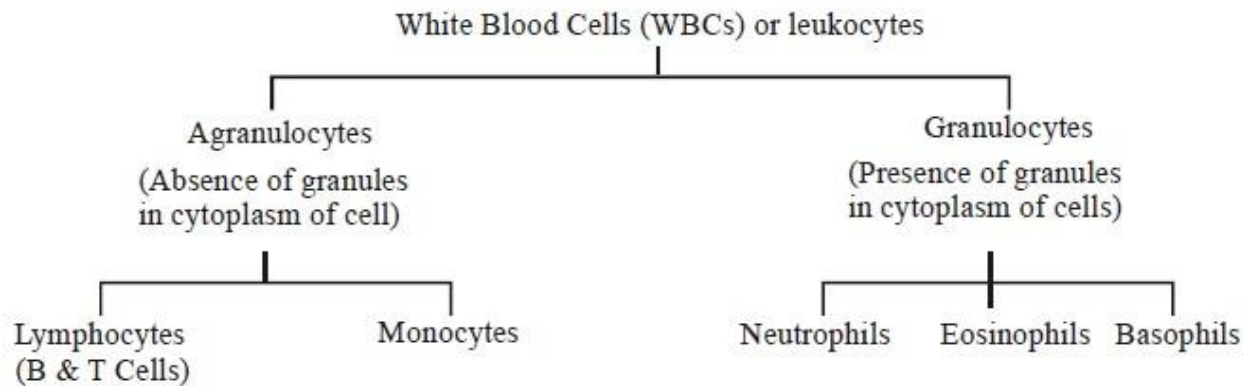
(i) Red Blood Cells (erythrocytes): The most numerous type in the blood.

- Women average about 4.8 million of these cells per cubic millimeter (mm^3 ; which is the same as a microliter [μl]) of blood.
- Men average about 5.4×10^6 per μl .
- These values can vary over quite a range depending on factors such as health and altitude.
- RBC precursors mature in the bone marrow closely attached to a macrophage.
- They manufacture haemoglobin until it accounts for some 90% of the dry weight of the cell.
- The nucleus is squeezed out of the cell and is ingested by the macrophage.
- No-longer-needed proteins are expelled from the cell in vesicles called exosomes.

The scanning electron micrograph shows the characteristic biconcave shape of red blood cells.

They live about 120 days and then are ingested by phagocytic cells in the liver and spleen. Most of the iron in their hemoglobin is reclaimed for reuse. The remainder of the heme portion of the molecule is degraded into bile pigments and excreted by the liver. Red blood cells are responsible for the transport of oxygen and carbon dioxide.

Anemia: Anemia is a shortage of RBCs and/or the amount of haemoglobin in them. Anemia has many causes. One of the most common is an inadequate intake of iron in the diet.

(ii) White Blood Cells (leukocytes)

White blood cells:

- are much less numerous than red blood cells (the ratio between the two is around 1:700),
- have nuclei,
- participate in protecting the body from infection,
- consist of lymphocytes and monocytes with relatively clear cytoplasm, and three types of granulocytes, whose cytoplasm is filled with granules.

a) Agranulocytes they are category of WBCs characterised by absence of granules in their cytoplasm. The 2 types of agranulocytes in blood circulation are lymphocytes and monocytes.

(i) Lymphocytes: There are several kinds of lymphocytes (although they all look alike under the microscope), each with different functions to perform. The most common types of lymphocytes are:

B lymphocytes (“B cells”). These are responsible for making antibodies.

T lymphocytes (“T cells”). There are several subsets of these:

Inflammatory T cells that recruit macrophages and neutrophils to the site of infection or other tissue damage.

Cytotoxic T lymphocytes (CTLs) that kill virus-infected and perhaps, tumor cells.

Helper T cells that enhance the production of antibodies by B cells.

Although bone marrow is the ultimate source of lymphocytes, the lymphocytes that will become T cells migrate from the bone marrow to the thymus where they mature. Both B

cells and T cells also take up residence in lymph nodes, the spleen and other tissues where they:

- encounter antigens.
- continue to divide by mitosis.
- mature into fully functional cells.

ii) Monocytes

Monocytes leave the blood and become macrophages and dendritic cells.

Macrophages are large, phagocytic cells that engulf foreign material (antigens) that enter the body and destroy the dead and dying cells of the body.

(b) Granulocytes

They are the category of WBCs characterised by presence of granules in cytoplasm. There are 3 types of granulocytes.

(i) Neutrophils

The most abundant of the WBCs. Neutrophils squeeze through the capillary walls and into infected tissue where they kill the invaders (e.g., bacteria) and then engulf the remnants by phagocytosis.

(ii) Eosinophils

The number of eosinophils in the blood is normally quite low (0–450/ μ l). However, their numbers increase sharply in certain diseases, especially infections by parasitic worms. Eosinophils are cytotoxic, releasing the contents of their granules on the invader.

(iii) Basophils

The number of basophils also increases during infection. Basophils leave the blood and accumulate at the site of infection or other inflammation. There they discharge the contents of their granules, releasing a variety of mediators such as histamine/serotonin prostaglandins and leukotrienes

Platelets or Thrombocytes

Platelets are cell fragments produced from megakaryocytes.

Blood normally contains 150,000–350,000 platelets per microliter (μl) or cubic millimeter (mm^3). This number is normally maintained by a homeostatic (negative-feedback) mechanism.

If this value should drop much below 50,000/ μl , there is a danger of uncontrolled bleeding because of the essential role that platelets have in blood clotting.

When blood vessels are cut or damaged, the loss of blood from the system must be stopped before shock and possible death occur. This is accomplished by solidification of the blood, a process called coagulation or clotting. A blood clot consists of a plug of platelets enmeshed in a network of insoluble fibrin molecules.

Functions of the blood

Blood performs two major functions:

A] Transport of :

- oxygen and carbon dioxide.
- food molecules (glucose, lipids, amino acids).
- ions (e.g., Na^+ , Ca^{2+} , HCO_3^-).
- wastes (e.g., urea).
- hormones.
- heat.

B] Maintain constant body temperature, i.e., Homeostasis.

HEART

Because of the crucial role of blood in our body, there is a need to circulate the blood continuously, we thus need a pumping organ to push blood around the body, a network of tubes to reach all the tissues and a system in place to ensure that this network can be repaired if damaged.

Structure of heart in different groups of animals

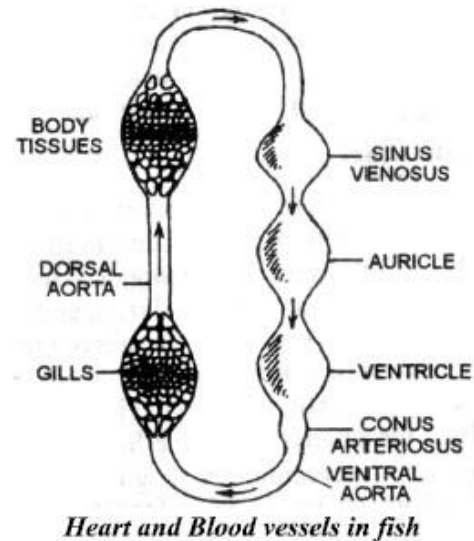
1. Birds and Mammals: Avian and mammalian heart is four chambered, having right and left auricle and right & left ventricle. The separation of right side and left side of the heart is useful to keep oxygenated and deoxygenated blood from mixing. Such separation allows a highly efficient supply of O_2 to the body.

This is useful in animals that have high energy needs, such as birds and mammals which constantly use energy to maintain their body temperature.

Thus, deoxygenated and oxygenated blood remain fully separated and there is complete double circulation, as blood goes to heart twice during each cycle.

2. Reptiles and Amphibia: They do not use energy to maintain their body temperature. Hence, they have 3- chambered hearts and tolerate some mixing of the oxygenated and deoxygenated blood streams.

3. Fishes: A fish heart handles only deoxygenated blood and is often called Venous heart. It is two chambered. The blood is pumped to gills, where it is oxygenated and then passes directly to rest of the body.



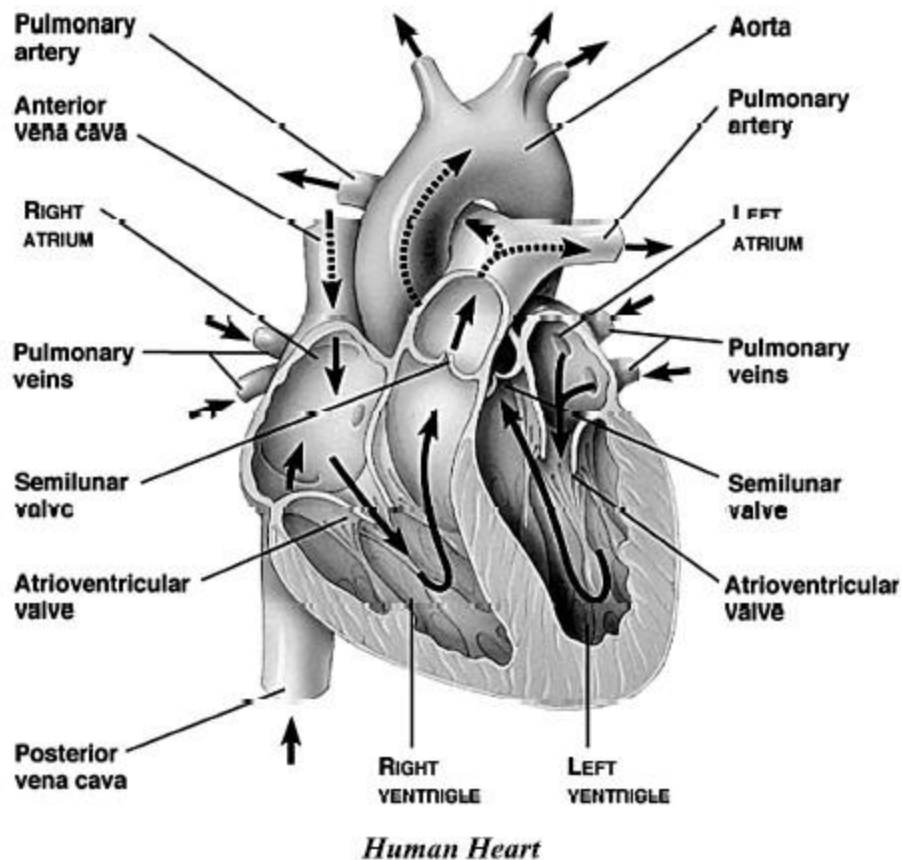
Human Heart

The heart is a hollow, muscular organ in vertebrates responsible for pumping blood through the blood vessels by repeated, rhythmic contractions. The term *cardiac* (as in cardiology) means “related to the heart” and comes from the Greek, *kardia*, for “heart”.

Structure

In the human body, the heart is normally situated slightly to the left of the middle of the thorax, underneath the sternum (breastbone). It is enclosed by a sac known as the pericardium and is surrounded by the lungs.

The *apex* is the blunt point at the base of the heart. A stethoscope can be placed directly over the apex and count the beats. In normal adults, its mass is 250-350 g, but extremely diseased hearts can be up to 1000 g in mass. It consists of four chambers, the two upper *atria* (singular: *atrium*) and the two lower *ventricles*.



A septum divides the right atrium and ventricle from the left atrium and ventricle, preventing blood from passing between them. Valves between the atria and ventricles (atrioventricular valves) maintain coordinated unidirectional flow of blood from the atria to the ventricles.

The function of the right side of the heart is to collect deoxygenated blood from the body and pump it into the lungs so that carbon dioxide can be dropped off and oxygen picked up, this exchange occurs through a process called diffusion. The left side collects oxygenated blood from the lungs and pumps it out to the body. On both sides, the lower ventricles are thicker than the upper atria.

Oxygen-depleted or deoxygenated blood from the body enters the right atrium through two great veins, the superior vena cava which drains the upper part of the body and the inferior vena cava that drains the lower part. The blood then passes through the tricuspid valve to the right ventricle. The right ventricle pumps the deoxygenated blood to the lungs, through the pulmonary artery. In the lungs gaseous exchange takes place and the blood releases carbon dioxide into the lung cavity and picks up oxygen. The oxygenated blood

then flows through pulmonary veins to the left atrium. From the left atrium this newly oxygenated blood passes through the mitral valve (also called the bicuspid valve) to enter the left ventricle. The left ventricle then pumps the blood through the aorta to the entire body. Even the lungs take some of the blood supply from the aorta via bronchial arteries. The left ventricle is much more muscular (1.3 - 1.5 cm thick) than the right (0.3 - 0.5 cm thick) as it has to pump blood around the entire body, which involves exerting a considerable force to overcome the vascular pressure. As the right ventricle needs to pump blood only to the lungs, it requires less muscle. Even though the ventricles lie below the atria, the two vessels through which the blood exits the heart (the pulmonary artery and the aorta) leave the heart at its top side.

The contractile nature of the heart is due to the presence of cardiac muscle in its wall which can work continuously without fatigue. The heart wall is made of three distinct layers. The first is the outer epicardium which is composed of a layer of flattened epithelial cells and connective tissue. Beneath this is a much thicker myocardium made up of cardiac muscle. The endocardium is a further layer of flattened epithelial cells and connective tissue which lines the chambers of the heart.

The blood supply to the heart itself is supplied by the left and right coronary arteries, which branch off from the aorta.

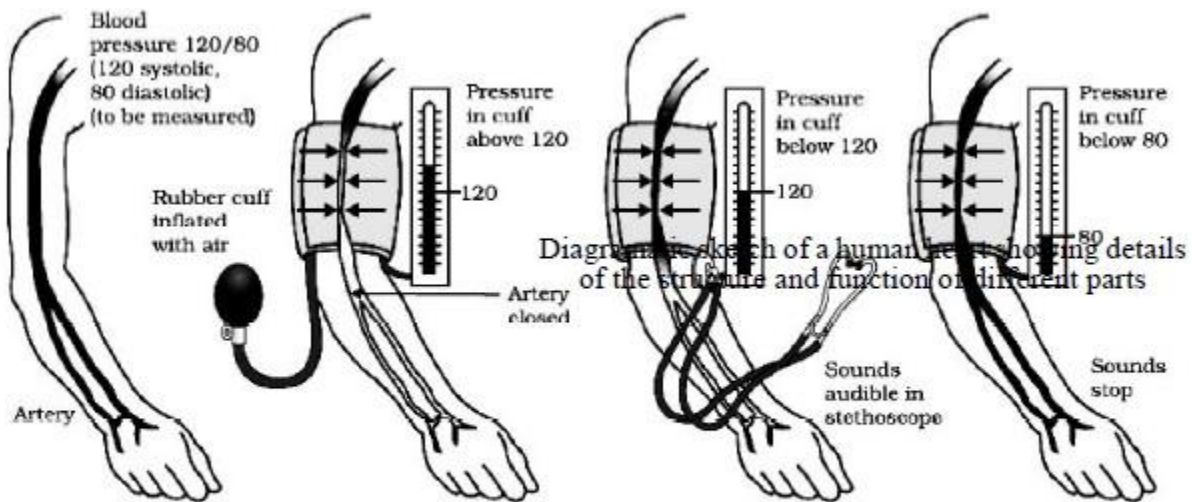
The tubes – blood vessels

Arteries are the vessels which carry blood away from the heart to various organs of the body. Since the blood emerges from the heart under high pressure, the arteries have thick, elastic walls. Veins collect the blood from different organs and bring it back to the heart. They do not need thick walls because the blood is no longer under pressure, instead they have valves that ensure that the blood flows only in one direction. On reaching an organ or tissue, the artery divides into smaller and smaller vessels to bring the blood in contact with all the individual cells. The smallest vessels have walls which are one-cell thick and are called capillaries. Exchange of material between the blood and surrounding cells takes place across this thin wall. The capillaries then join together to form veins that convey the blood away from the organ or tissue.

Blood pressure

The heart has to develop a high pressure so that blood can be pumped through the fine capillaries. Without this pressure of flowing blood, the capillaries would be flat just like a balloon without air pressure in it. This blood pressure varies from one part of body to another. The average when it contracts and empties itself into the aorta is called the systolic pressure. The systolic pressure is equal to that exerted by a column of 120 mm of mercury (Hg). The opposite state is the diastolic pressure which is produced when the ventricles are filling with blood from the auricles. The diastolic pressure is usually 80mm of Hg. The blood pressure is measured in left brachial artery located just above the elbow by an instrument called sphygmomanometer.

For a healthy heart of a resting adult person, it is typically 120/80. Blood pressure varies from person to person and is affected by factors such as age, sex, heredity and physical and emotional states.



Measurement of blood pressure by sphygmomanometer

The cardiac cycle

The function of the heart is to pump blood through the body. Every single beat of the heart involves a sequence of events known as the cardiac cycle, which consists of three major stages: atrial systole, atria and the corresponding influx of blood into the ventricles. Once the blood has fully left the atria, the atrioventricular valves, which are situated between the atria and ventricular chambers, close. This prevents any backflow into the atria. It is

the closing of the valves that produces the familiar beating sounds of the heart, commonly referred to as the “lub-dub” sound due to the closing of the semilunar and atrioventricular valves.

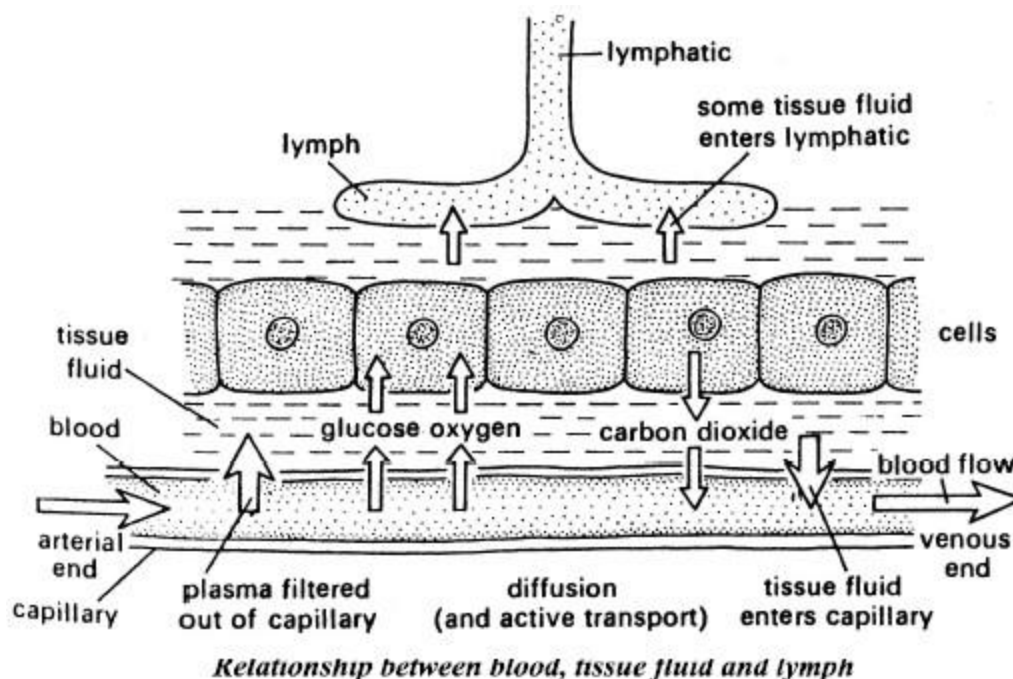
The ventricular systole consists of the contraction of the ventricles and flow of blood into the circulatory system. Again, once all the blood empties from the ventricles, the pulmonary and aortic semilunar valves close. Finally complete cardiac diastole involves relaxation of the atria and ventricles in preparation for refilling with circulating blood.

Lymph

The circulatory system of man is not closed in the strict sense. At the tissue level, leakage of leucocytes and plasma containing respiratory gases (oxygen), nutrients (glucose, amino acids, and salts) and hormones, takes place from the blood capillaries. The tissue cells, therefore, get bathed with this fluid called tissue fluid. From this the cells extract the oxygen, glucose, amino acids, etc., which they need for their living processes and into it they excrete their carbon dioxide and nitrogenous wastes. Some of the tissue fluid returns back to the capillaries towards the venous end. However, most of tissue fluid returns to blood stream via the lymphatic system.

Lymphatic system runs parallel to the veins. It collects the tissue fluid, now called lymph, in the blindly ending, thin-walled channels or lymphatics which unites to form two main lymph ducts. Both ducts then open into a pair of veins (right and left subclavian veins) entering the right atrium.

Thus, lymph forms another medium of circulation in human body. Proteins which cannot reenter the bloodcapillaries because of their size, return to circulation by the lymphatic fluid. The lymph is light yellow in colour and not red since it lacks hemoglobin. However, its composition is similar to blood plasma. The lymph also flows in one direction, that is, from the tissues to the heart.



EXCRETION

Excretion in Plants

The main waste products produced by plants are carbondioxide, water vapour and oxygen. Carbon dioxide and water vapour are produced as wastes during respiration whereas oxygen is produced as a waste during photosynthesis. The gaseous wastes of photosynthesis and respiration in plants are removed through stomata in leaves and lenticels in stem and released to the air. The plants excrete carbon dioxide produced as a waste during respiration only at night time and oxygen is excreted as a waste only during the day time. Water vapour produced as a waste is excreted by the plants all the time by transpiration. Stomata are found mostly on the leaves. Young stem, flowers and fruits also have a few stomata.

Stomata are tiny pore complexes found in the epidermis of plants. Each stoma is surrounded by two small but specialized green epidermal cells called guard cells. The number of stomata on the leaf surface varies from 1000 to 60,000 per cm^2 .

Guttation

Removal of excess of water from the plants in the form of the droplets is known as guttation. The pores through which water is removed is known as hydathode. Hydathodes

are special types of stomata called water stomata. The fluid, which oozes out in guttation, contains a variety of dissolved inorganic and organic substances.

Differences between Transpiration and Guttation

Guttation	Transpiration
1. Water loss in the form of water drops.	1. Water loss in the form of vapour.
2. Occurs through hydathodes.	2. Occurs through stomata, cuticle or lenticels.
3. Usually occurs during night.	3. Usually occurs during day time.
4. Guttation takes place due to the development of root presence.	4. Root pressure is not involved.

Plant waste products

The plants also store some of the waste products in their body parts. For example, some of the waste products like crystals, resins, tannins, dyes, gums, essential oils etc. collect in the leaves, bark and fruits of the plants (or trees). The plants get rid of these wastes by shedding of leaves, peeling of bark and felling of fruits. Wastes get stored in the fruits of the plant in the form of solid bodies called raphides. These wastes are removed when the fruits get detached from the plant. Raphides are also stored in underground stem like yam (yam). Raphides are made of calcium oxalate crystals.

Certain plant wastes that are useful to humans are natural rubber, resins, gums, essential oils like sandalwood oil, eucalyptus oil, clove oil, lavender oil, etc.

Plants waste can be classified as follows:

- ❖ Solid wastes in plants : rubber, cystoliths.
- ❖ Liquid wastes in plants : Sandalwood oil, eucalyptus oil, clove oil, lavender oil etc.
- ❖ Gaseous wastes in plants : Carbon dioxide and oxygen.

II. Excretion in Animals

The biological process involved in removal of harmful metabolic wastes from the body is called excretion. Different organisms use varied strategies to do this.

1. Excretion in Amoeba: In Amoeba CO₂ is mostly excreted out by diffusion through general body surface. It is considered that the contractile vacuoles also play some role in removal of excretory products.

2. Excretion in Earthworm: In earthworm the excretory organs are nephridia. They are characterized by the presence of a ciliated funnel shaped opening or nephrostome. Nephrostome directs coelom full of waste substances to pass through the tubule of nephredium. Earthworm has three types of nephridia – septal, pharyngeal & integumentary. Septal and pharyngeal nephridia are enteronephric in which excretory fluid is passed into alimentary canal. Integumentary nephridia is exonephric in which the waste product is discharged to exterior.

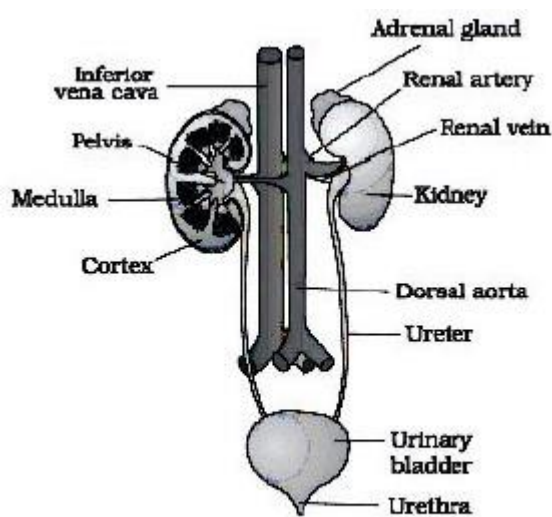
3. Excretion in human beings: The excretory system of human beings includes a pair of kidneys, a pair of ureters, a urinary bladder and a urethra. Kidneys are located in abdomen, one on either side of the backbone. Urine produced in kidneys passes through ureters into urinary bladder where it is stored until it is released through urethra.

EXCRETORY SYSTEM OF HUMAN BEING

Human excretory system consists of a pair of kidneys, a pair of ureters, an urinary bladder and an urethra. Kidneys are principal excretory organs which are filled with a number of microscopic tubules called nephrons.

In humans, the kidneys are located behind the abdominal cavity. There are two, one on each side of the spine. The right kidney sits just below the diaphragm and posterior to the liver, the left below the

diaphragm and posterior to the spleen. Resting on top of each kidney is an adrenal gland. The asymmetry within the abdominal cavity caused by the liver typically results in the right



Human Excretory System

kidney being slightly lower than the left, kidney being located slightly more medial than the right.

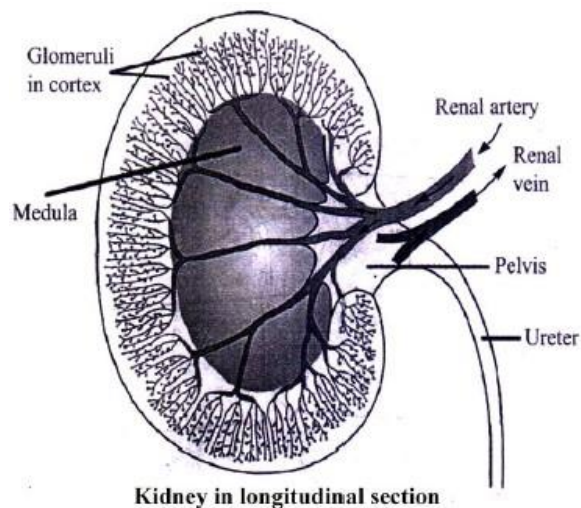
The Kidney

The kidney has a bean-shaped structure, each kidney has concave and convex surfaces. The concave surface, the renal hilum, is the point at which the renal artery enters the organ and the renal vein and ureter leave. The kidney is surrounded by tough fibrous tissue, the renal capsule.

The substance or parenchyma, of the kidney is divided into two major structures - superficial is the renal cortex and deep is the renal medulla. Grossly, these structures take the shape of 8 to 18 cone-shaped renal lobes, each containing renal cortex surrounding a portion of medulla called renal pyramid (of Malpighi).

Between the renal pyramids are projections of cortex called renal columns (of Bertin). Nephrons, the urine-producing functional structures of the kidney, span the cortex and medulla. The initial filtering portion of a nephron is the renal corpuscle, located in the cortex, which is followed by renal tubule that passes from the cortex deep into the medullary pyramids.

Part of the renal cortex, a medullary ray is a collection of renal tubules that drain into a single collecting duct. The tip or papilla, of each pyramid empties urine into a minor calyx, minor calyces empty into major calyces, and major calyces empty into the renal pelvis, which becomes the ureter.



The urine produced in the kidneys constantly flows through the ureters and collects in the urinary bladder. The urine is emptied from the urinary bladder to the outside of the body through the urethra. The openings of the ureters are somewhat projecting and act like valves to prevent the backflow of urine when the bladder contracts to pass out the urine.

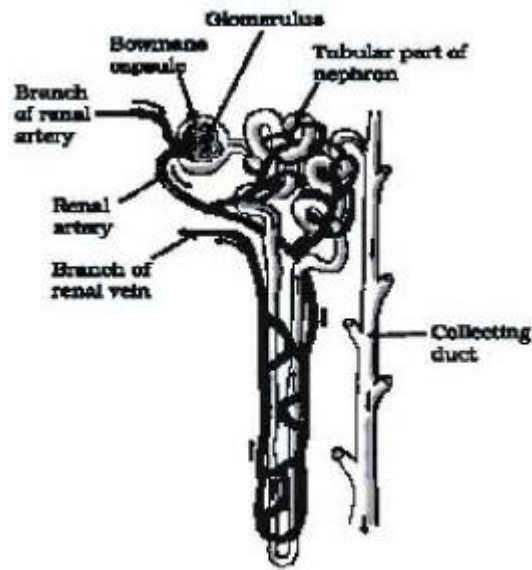
A sphincter guards the opening of the bladder into the urethra and relaxes only at the time of urination under an impulse from the brain.

The Nephron

Each kidney has large number of filtration units called nephrons packed close together.

The nephron is a tube closed at one end and open at the other. It consists of a:

- **Bowman's capsule.** Located at the closed end, the wall of the nephron is pushed in forming a double-walled chamber.
- **Glomerulus.** A capillary network within the Bowman's capsule. Blood leaving the glomerulus passes into a second capillary network surrounding the Henle's loop.
- **Proximal convoluted tubule.** Coiled and lined with epithelial cells having microvilli and stuffed with mitochondria.
- **Loop of Henle.** It makes a hairpin turn and returns to the following structures:
 - i) Distal convoluted tubule: which is also highly coiled and surrounded by capillaries.
 - ii) Collecting tubule. It leads to the pelvis of the kidney from where urine flows to the bladder, and periodically, on to the outside world.



Structure of nephron

Formation of Urine

It takes place in three steps:

- Ultrafiltration.
- Secretion.
- Reabsorption.

The nephron makes urine by:

- ❖ filtering the blood of its small molecules and ions.
- ❖ reclaiming the needed amounts of useful materials.
- ❖ Surplus or waste molecules and ions are left to flow out as urine.

The steps:

- Blood enters the glomerulus under pressure.
- This causes water, small molecules (but not macromolecules like proteins) and ions to filter through the capillary walls into the Bowman's capsule. This fluid is called nephric filtrate.
- Nephric filtrate collects within the Bowman's capsule and then flows into the proximal tubule.
- Here all of the glucose, and amino acids, >90% of the uric acid, and ~60% of inorganic salts are reabsorbed by active transport.
- The active transport of Na^+ out of the proximal tubule is controlled by angiotensin II.
- The active transport of phosphate (PO_4^{3-}) is regulated by the parathyroid hormone.
- As the fluid flows into the descending segment of the loop of Henle, water continues to leave by osmosis because the interstitial fluid is very hypertonic. This is caused by the active transport of Na^+ out of the tubular fluid as it moves up the ascending segment of the loop of Henle.
- In the distal tubules, more sodium is reclaimed by active transport, and still more water follows by osmosis.
- Final adjustment of the sodium and water content of the body occurs in the collecting tubules.

The Kidney and Homeostasis

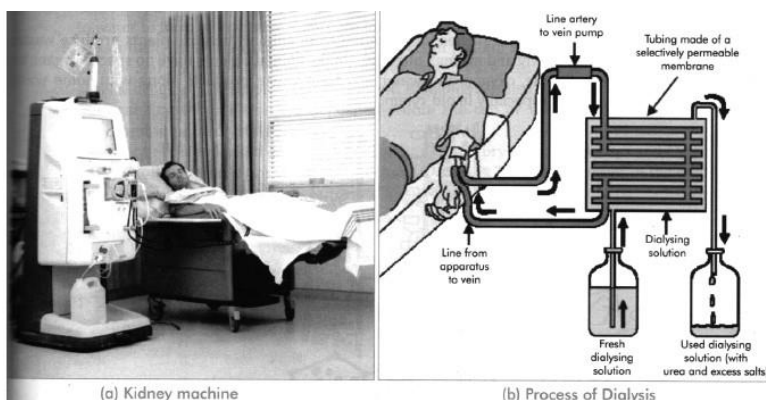
While we think of the kidney as an organ of excretion, it is more than that. It does remove wastes, but it also removes normal components of the blood, that are present in greater-than-normal concentrations. When excess water, sodium ions, calcium ions, potassium ions, and so on are present, the excess quickly passes out in the urine. On the other hand, the kidneys step up their reclamation of these same substances when they are present in the blood in less-than-normal amounts. Thus the kidney continuously regulates the chemical composition of the blood within narrow limits. The kidney is one of the major homeostatic devices of the body.

Dialysis: This process is used in artificial kidney. Small molecules like urea are removed from the blood because they are free to diffuse between the blood and the bath fluid, whereas large molecules (e.g., plasma proteins) and cells remain confined to the blood.

The bath fluid must already have had essential salts added to it to prevent the dangerous loss of these ions from the blood. Note that blood and bath fluid flow in opposite directions across the dialysis membrane. This “counter-current” exchange maintains a diffusion gradient through the entire length of the system. An anticoagulant is added to the blood, so it will not clot while passing through the machine. The anticoagulant is neutralized as the blood is returned to the patient.

Artificial kidneys: Kidneys are vital organs for survival of human beings. These remain active and executive through out the life, but it may lose its efficiency gradually due to infections, injury or restricted blood flow and ageing. These abnormalities cause dysfunctioning and damage of kidneys. This process is called kidney failure. This leads to accumulation of poisonous wastes in the body that can even lead to death.

In case of kidney failure, an artificial kidney can be used. An artificial kidney is a device to remove nitrogenous waste products from the blood through dialysis. The blood of a patient having kidney failure can be cleaned regularly by using dialysis machine (or commonly known as kidney machine).



Mechanism: Artificial kidneys contain a number of tubes with a semi-permeable lining, suspended in a tank with dialysing fluid solution. It contains water, glucose and salts in similar concentration to those in the normal blood. This fluid has the same osmotic pressure as blood, except that it is devoid of nitrogenous wastes. The patient's blood is passed through these tubes. During this passage, the waste products from the blood pass into dialysing fluid by diffusion. The purified blood is pumped back into the patient. This is similar to kidney function, but it is also different in that there is no reabsorption involved.

Normally, in a healthy adult, the initial filtrate in the kidney is about 180 L daily. However, the volume actually excreted is only a litre or two a day, because the remaining filtrate is reabsorbed in the kidney tubules.

REVISION EXERCISE

Very Short Answer Questions

1. What is symbiosis?
2. What are stomata?
3. What is the function of pseudopodia in Amoeba?
4. What is the name given to the muscles present in the human heart?
5. What is the name given to the largest artery present in our body?

Short Answer Questions

1. Is donating blood harmful for our body?
2. What is blood transfusion ?
3. How body prevents loss of blood during injury?
4. What is transportation of food? In which form food is transported?
5. Where are the valves located in the heart? What is the function of these valves?

Long Answer Questions

1. Why are plants green in colour?
2. What are villi? Where are they present? What is their function?
3. How digestive juices are secreted in the alimentary canal?
4. Which is the last step in respiration? Where does it occur?
5. What is Rh factor? What is its importance?
6. Give differences between blood and lymph.
7. What is plasma? What are the various functions of plasma?
8. Explain the function performed by bile and pancreatic juice, which enters the duodenum through a common duct.
9. What are ulcers? How are they caused?
10. Explain the mechanism of breathing.

11. Explain the mechanism of blood circulation?
12. How does excretion takes place in earthworm?

MULTIPLE CHOICES

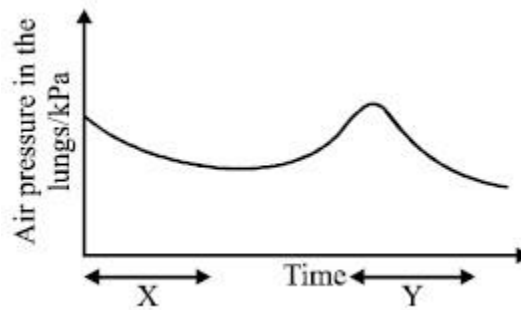
LEVEL – 1

1. Which of the following statements about the autotrophs is incorrect?
 - (a) They synthesise carbohydrates from carbon dioxide and water in the presence of sunlight and chlorophyll
 - (b) They store carbohydrates in the form of starch
 - (c) They convert carbon dioxide and water into carbohydrates in the absence of sunlight
 - (d) They constitute the first trophic level in food chains
2. Which is the correct sequence of parts in human alimentary canal?
 - (a) Mouth →stomach → small intestine → oesophagus → large intestine
 - (b) Mouth → oesophagus → stomach → large intestine → small intestine
 - (c) Mouth → stomach → oesophagus → small intestine → large intestine
 - (d) Mouth → oesophagus → stomach → small intestine → large intestine
3. If salivary amylase is lacking in the saliva, which of the following events in the mouth cavity will be affected?
 - (a) Proteins breaking down into amino acids
 - (b) Starch breaking down into sugars
 - (c) Fats breaking down into fatty acids and glycerol
 - (d) Absorption of vitamins
4. The inner lining of stomach is protected by one of the following from hydrochloric acid. Choose the correct one:
 - (a) Pepsin
 - (b) Mucus
 - (c) Salivary amylase
 - (d) Bile
5. A few drops of iodine solution were added to rice water. The solution turned blue-black in colour. This indicates that rice water contains
 - (a) complex proteins
 - (b) simple proteins
 - (c) fats
 - (d) starch
6. Choose the function of the pancreatic juice from the following

- (a) trypsin digests proteins and lipase carbohydrates
 - (b) trypsin digests emulsified fats and lipase proteins
 - (c) trypsin and lipase digest fats
 - (d) trypsin digests proteins and lipase emulsified fats
7. Which of the following statement(s) is (are) true about respiration?
- (i) During inhalation, ribs move inward and diaphragm is raised
 - (ii) In the alveoli, exchange of gases takes place i.e., oxygen from alveolar air diffuses into blood and carbon dioxide from blood into alveolar air
 - (iii) Haemoglobin has greater affinity for carbon dioxide than oxygen
 - (iv) Alveoli increase surface area for exchange of gases
- (a) (i) and (iv) (b) (ii) and (iii) (c) (i) and (iii) (d) (ii) and (iv)
8. During respiration exchange of gases take place in:
- (a) trachea and larynx (b) alveoli of lungs
 - (c) alveoli and throat (d) throat and larynx
9. Which of the following statement (s) is (are) true about heart?
- (i) Left atrium receives oxygenated blood from different parts of body while right atrium receives deoxygenated blood from lungs
 - (ii) Left ventricle pumps oxygenated blood to different body parts while right ventricle pumps deoxygenated blood to lungs
 - (iii) Left atrium transfers oxygenated blood to right ventricle which sends it to different body parts
 - (iv) Right atrium receives deoxygenated blood from different parts of the body while left ventricle pumps oxygenated blood to different parts of the body
- (a) (i) (b) (ii) (c) (ii) and (iv) (d) (i) and (iii)
10. Choose the correct path of urine in our body
- (a) kidney → ureter → urethra → urinary bladder
 - (b) kidney → urinary bladder → urethra → ureter
 - (c) kidney → ureters → urinary bladder → urethra
 - (d) urinary bladder → kidney → ureter → urethra

LEVEL – II

1. The given graphs shows changes in air pressure in the lungs during breathing. What causes the change in air pressure during period X?



- (a) Contraction of the diaphragm muscles
 (b) Decrease in the volume of the lungs
 (c) Movement of ribs downward and inward
 (d) Relaxation of the external intercostal muscles
2. Gita is supposed to face an interview. During the first five minutes before the interview she experiences sweating, increased rate of heart beat, increased respiratory rate, etc. Which of the following hormones has increased in her blood and is responsible for her restlessness?

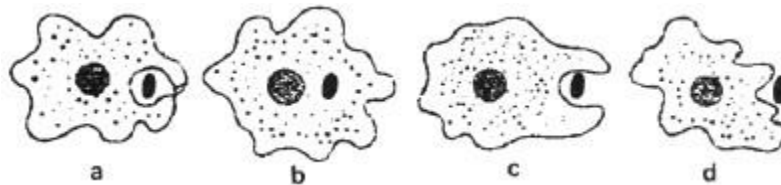
(a) GnRH (b) Estrogen (c) Adrenaline (d) Insulin

3. Glucose $\xrightarrow{\text{In cytoplasm}}$ P $\xrightarrow{\text{In muscle cells}}$ Q + Energy

The above given flow chart shows one of the pathway of glucose break-down. Identify 'P' and 'Q'.

(a) Ethanol and carbon dioxide (b) Pyruvate and carbon dioxide
 (c) Pyruvate and lactate (d) Ethanol and pyruvate

4. The given figures show holozoic nutrition in Amoeba but in random order. Arrange the figures in correct sequence so as to give complete steps of nutrition.

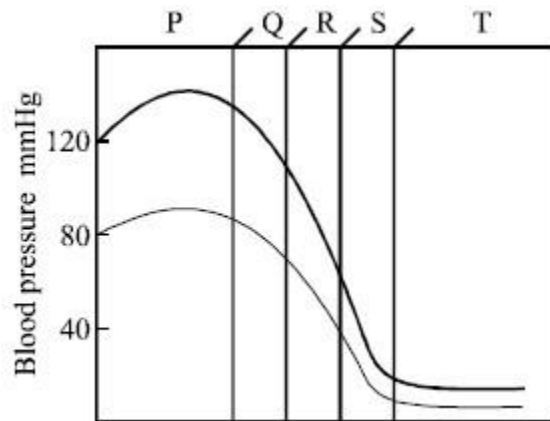


(a) b, c, a and d (b) a, b, d and c (c) d, c, a and b (d) d, a, c and b

5. Various technical terms related to respiratory system of different organisms are hidden in the given word grid. Which of the following is not present in the given word grid?

R	M	S	L	U	N	G
I	G	I	L	L	N	T
B	A	O	I	D	O	R
C	R	M	Y	M	S	A
A	H	A	A	N	T	C
G	P	T	B	Z	R	H
E	A	A	T	S	I	E
P	I	R	A	C	L	A

- (i) The air tubes of insects.
 (ii) Skeletal structure which protects the lungs.
 (iii) The opening through which humans inhale air.
 (iv) Small opening on the sides of the body of an insect.
 (v) A flap like structure which covers the glottis at the time of swallowing in humans.
 (vi) Respiratory organ of fish.
- (a) (i) and (ii) only
 (b) (ii), (v) and (vi) only
 (c) (iii) and (iv) only
 (d) (iv) and (v) only
6. The given graph represents the pressure (systolic and diastolic) of a volume of blood moving through circulatory system via different blood vessels labelled as P, Q, R, S and T.



Match the vessels given in Column - I with their corresponding letters given in Column -II and select the correct option.

Column -I

Column - II

(A) Venules

(i) P

(B) Capillaries

(ii) T

(C) Arterioles

(iii) R

(D) Veins

(iv) Q

(E) Arteries

(v) S

(a) (A) – (i), (B) – (iv), (C) – (ii), (D) – (iii), (E) – (v)

(b) (A) – (i), (B) – (iii), (C) – (v), (D) – (iv), (E) – (ii)

(c) (A) – (v), (B) – (iii), (C) – (iv), (D) – (ii), (E) – (i)

(d) (A) – (ii), (B) – (iii), (C) – (iv), (D) – (v), (E) – (i)

7. Read the given statements and select the correct option.

Statement - 1: Chloroplast and mitochondria are semi-autonomous organelles.

Statement - 2: Chloroplast and mitochondria have their own DNA and protein synthesizing machinery.

(a) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.

(b) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1.

(c) Statement 1 is true and statement 2 is false.

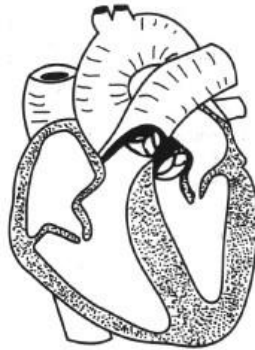
(d) Both statements 1 and 2 are false.

8. Read the given statements and select the correct option.

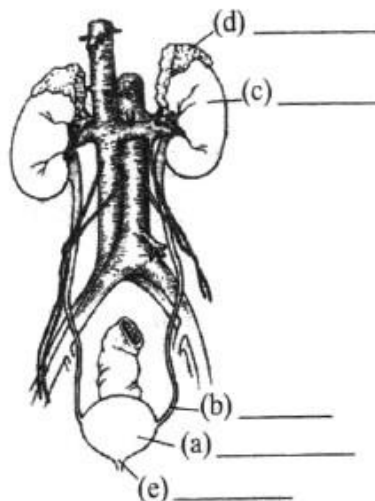
Statement- 1: Human lungs have enormous surface area for exchange of gases.

Statement - 2: In humans, glottis is guarded by epiglottis.

- (a) Both statements 1 and 2 are true and statement 2 is the correct explanation of statement 1.
- (b) Both statements 1 and 2 are true but statement 2 is not the correct explanation of statement 1.
- (c) Statement 1 is true and statement 2 is false.
- (d) Both statements 1 and 2 are false.
9. The diagram below shows the transverse section view of the mammalian heart.
- (a) Label the following structures on the diagram, right and left atria, right and left ventricles, superior and inferior vena cava, aorta, pulmonary artery and vein, right and left atrio-ventricular valves, pulmonary and aortic semilunar valves.



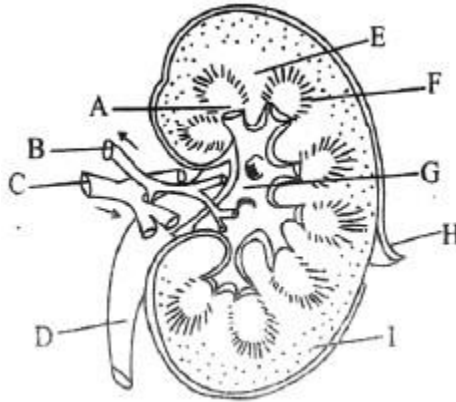
- (b) On the diagram of the heart shown below indicate the direction of blood flow through the heart. Use red to show the pathway of oxygen-rich blood and blue to show the pathway of oxygen poor blood.
10. Study the given figure of excretory system of man carefully and answer the following questions:



(i) Name the parts labelled as (a), (b), (c), (d) and (e).

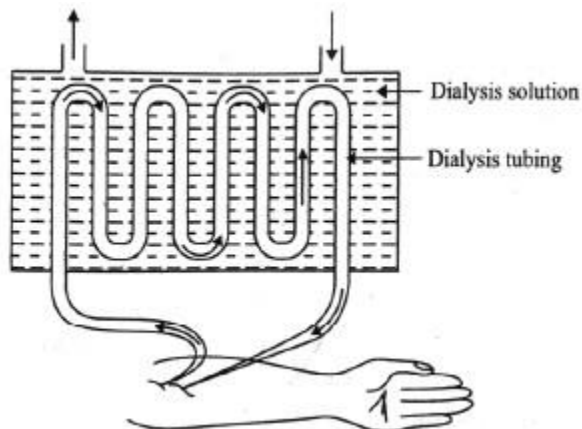
(ii) Give one major function of each of these parts.

11. Match the structure with the correct letter from the diagram at the right.



_____	Minor calyx	_____	Renal artery
_____	Renal capsule	_____	Renal column
_____	Renal cortex	_____	Renal pelvis
_____	Renal pyramid	_____	Renal vein
_____	Ureter		

12. The figure below shows a simplified version of a kidney dialysis machine.



(a) What do you notice about the direction of the flow of blood and the dialysis solution?

(b) Explain why red blood cells remain inside the dialysis tubing.

(c) People who use kidney machines need a special diet. Suggest one difference between their diet and a normal diet.

(d) If a person suffers from low blood pressure, this may lead to kidney failure. Explain how this might happen.

(e) the kidney machine is sometimes referred to as an 'artificial kidney'. Justify

13. Complete the digestion table.

Organ	Secretion	Enzyme	Nutrient	Product after digestion
Stomach		Pepsin		Proteoses
	Pancreatic juice	Tearing	Protein	Peptides and amino acids
Ileum		Lipase		
Ileum		Sucrase		
Colon	None	None	None	

14. The following paragraph is related to assimilation of food by our body. Complete the paragraph by selecting suitable words from those given in the box. You can use the term only once.

Hepatic portal, excess glucose, subcutaneous, amino acids, deamination, fatty acids, glycerol, glycogen, proteins, lymphatic, absorbed, carried, empties.

The food digested and _____ by the gut are transported in two ways. Simple sugar, amino acids, vitamins and minerals, etc., are _____ to the liver by the _____ vein. The liver converts any _____ into soluble _____ which can be temporarily stored. The _____ circulate in the body and they serve as building blocks of _____. The amino acids are broken down in the liver by a process called _____ in which the nitrogen-containing amino group is removed and converted into urea for excretion. The _____ and _____ absorbed by the gut are transported mainly through the intestinal villi and _____ system. The thoracic duct of the lymphatic system _____ into large veins carrying blood to the heart. Some fats are used in the synthesis of certain compounds in the body cells. The excess quantity of fat gets deposited chiefly below the skin as _____ fat.

15. Match the Following.

Column A

Column B

- | | |
|--------------------------|--|
| (A) Ingestion | (i) Transport of nutrients from lumen to blood |
| (B) Mechanical digestion | (ii) Enzymatic breakdown |
| (C) Chemical digestion | (iii) Elimination of faeces |
| (D) Absorption | (iv) Eating |
| (E) Defecation | (v) Chewing |
| | (vi) Churning |
| | (vii) Includes swallowing |
| | (viii) Segmentation and peristalsis |

16. Match the Following.

Column A

- (A) Gastrin
- (B) Bile
- (C) Peptidase
- (D) Amylase
- (E) Lipase
- (F) Enterokinase
- (G) HCl

Column B

- (i) Emulsifies fats
- (ii) Converts pepsinogen to pepsin
- (iii) Converts proteins into aminoacids
- (iv) Stimulates secretion of HCl
- (v) Converts starch and glycogen into disaccharides
- (vi) Activates trypsin secreted from pancreas
- (vii) Converts fats into fatty acid and glycerol