CHAPTER 12

NUTRITION

In a very real sense, you are what you eat. Atoms from your food make up most of the molecules of your body, energy derived from food powers your brain, your muscles and all the cells of your body. Even the first cells must have obtained materials and energy from their environment to grow and carry on cellular processes. An organisms evolved the ways they gained material diversified dramatically.

12.1 INTRODUCTION

Every living organism requires energy to perform its metabolic functions an molecules to build up its body. For this, they adopt the way familiarly known a **nutrition**. So, nutrition is the process by which the organisms obtain energy t maintain the function of life, to build the matter and maintain their structure Nutrients are food or any substance which supplies elements and energy to th living body for its metabolic activity.

Both the synthesis of new protoplasm and the respiratory oxidation of hi energy organic compounds demand the procurement of two main categories molecules from the environment: (1) already synthesized high energy compounc or else the raw materials from which new protoplasm can be synthesized and (2) th oxygen used in cellular respiration.

The main nutrients for living organisms are generally CO_2 and H_2O use directly or indirectly. On one hand, CO_2 and H_2O used directly by living organism to produce high energy organic molecules with the help of light or chemical ener where CO_2 is used as source of carbon for organic molecules. On the other han CO_2 and H_2O are used indirectly in the living organisms, they use already fixed C (organic molecules) as a source of carbon and energy for the synthesis of oth biomolecules.

12.2 AUTOTROPHIC AND HETEROTROPHIC NUTRITION

Living organisms can be divided into two groups on the basis of their mo of nutrition.

(i) **Autotrophic** organisms prepare their own food from the raw materia

(ii) **Heterotrophic** organisms obtain the prepared food from th surroundings.

Autotrophic nutrition is the type of nutrition in which organic compoun are manufactured by living organisms from available inorganic raw materials take from their surroundings. These molecules of raw materials are small and a soluble enough to pass through cell membrane. In autotrophic nutrition th nutrients do not require to be pretreated or digested before taking them into the cells. There are two methods of autotrophic nutrition i.e. ***phototrophic*** an ***chemotrophic*** nutrition.

Most of the autotrophic organisms have phototrophic mode of nutritio although a few have chemotrophic nutrition. All the plants, algae and some bacter are phototrophic while some bacteria are chemotrophic.

Heterotrophic nutrition is the type of nutrition in which organic compoun are not manufactured from simple inorganic nutrients. Such heterotrophic organism must obtain pre-fabricated organic molecules from their environment. Many of the organic molecules found in nature are too large to be absorbed unaltered through cell-membranes, they must first be broken down into smaller, more easily absorbable molecular units i.e. they must be digested. Most bacteria, fungi and animals have heterotrophic mode of nutrition. Carbohydrates, fats and proteins are the main classes of organic compounds serving as energy and carbon sources for heterotrophic organisms.

12.3 AUTOTROPHIC NUTRITION

As we already discussed that the mode of nutrition in which organic molecules are manufactured from simple inorganic molecules by using light energy or chemical energy is called autotrophic nutrition.

There are two types of autotrophic nutrition:

(1) Phototrophic nutrition (2) Chemotrophic nutrition

1. Phototrophic nutrition:

The organisms which have ability to convert solar energy into food energy are called phototrophic organisms. The raw materials needed by these organisms are carbon dioxide and water which supply the carbon, hydrogen and oxygen for the synthesis of organic molecule. CO_2 and H_2O are not the only nutrients material for green plants. The minerals like **Nitrogen**, **Phosphorous**, **Sulphur** and **Magnesium** etc. are also required to produce different molecules. It means three classes of nutrients are needed by green plants i.e. CO_2, H_2O and minerals. Besides all these three types of nutrients, the phototrophic organisms require green pigments i.e. chlorophyll **'a'**, **'b'** or other to absorb the energy from the universal source i.e. sun light. In the presence of the light these nutrients are used to synthesize energy rich compound, carbohydrate. This process is called **photosynthesis**.

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

Detailed process of photosynthesis is already discussed in chapter 11.

Other types of photosynthetic autotrophs are photosynthetic bacteria. They are unique because they are the only organism which are capable of synthesizing carbohydrate food without chlorophyll 'a'. This photosynthesis is different from photosynthesis in green plants, because they grow in light, and usually in sulphur spring where hydrogen sulphide (H_2S) is normally present. Hydrogen is provided by donor substances such as H_2S instead of water and sunlight is used as a source of energy. Therefore free oxygen is not released as a by product in bacterial photosynthesis. The process takes place at low expenditure of energy.

Two common examples of photosynthetic bacteria are the purple-sulphur bacteria and green sulphur bacteria. The former contain ***bacterio-***

chlorophyll and ***carotenoids*** as photosynthetic pigments and later ***chlorobium chlorophyll***. Both use H_2S as a donor of hydrogen. Light splits hydrogen sulphide in both cases. Hydrogen combines with carbon dioxide to form CH_2O.

$$2H_2S + CO_2 \xrightarrow{\text{Light}} (CH_2O)_n + H_2O + 2S$$

There are non-sulphur purple and brown bacteria found in the mud and stagnant water. They are photosynthetic and contain bacterio chlorophyll pigment. They use organic hydrogen donors whereas sulphur is not the by product in their cases. Light is still the source of energy.

2. Chemotrophic nutrition:

Their is another mode of autotrophic nutrition in which light is not used as the source of energy for nutritional requirement. In this type of nutrition, energy is produced by the oxidation of certain inorganic substances such as ammonia, nitrates, nitrites, ferrous ions, hydrogen sulphide and a number of metallic and non-metallic materials available in the environment. This energy is used for the synthesis of carbohydrates. This type of nutrition is called ***chemotrophic nutrition*** and the process of manufacturing food is called Chemosynthesis (chemo=chemical, synthesis=to produce). The organisms which synthesize high energy organic compounds by chemosynthesis are called chemosynthetic organisms. Chemosynthetic organisms are mainly bacteria, e.g. Ammonia using bacteria.

$$NH_4^+ + 3O_2 \longrightarrow 2NO_2^- + 2H_2O + 4H^+ + \text{energy}$$

Another bacterium oxidizes nitrites (NO_2^-) to nitrates

$$2NO_2^- + O_2 \longrightarrow 2NO_3^- + \text{energy}$$

Details of chemosynthetic bacteria are already discussed in section III, chapter-6.

The chemosynthetic bacteria that act on nitrogen compounds do play an extremely important role in the maintenance of nitrogen balance within the life system.

12.4 MINERAL NUTRITION IN PLANT

In plants, the source of inorganic requirements are minerals obtained directly or indirectly from the soil. These elements are known as mineral nutrients and the nutrition is called **mineral nutrition**. Nitrogen is also included in the mineral nutrients because it is normally obtained by the plant from soil whereas it is not a mineral element.

2.4.1 Role of some important mineral nutrients and their deficiency symptoms:

Analysis of plant shows the presence of a large number of mineral elements. he amount and number of elements present in plant may also differ from plant to lant, place to place and medium to medium in which the plant grows. Some nportant mineral nutrients which are required in large quantities (macronutrients) re as follows.

> Nitrogen, phosphorus and potassium are most important elements, used in the manufacture of modern fertilizers. Modern commercial fertilizers are often designated by their N-P-K percentages e.g the widely used garden fertilizers called 5-10-5 contains 5% nitrogen, 10% phosphoric acid and 5% soluble potash by weight.

) Nitrogen (N):

It is found in the soil in the form of nitrates or ammonium salts. It is an ssential constituent of proteins, nucleotides, nucleic acids and many other rganic molecules like chlorophyll, so the biosynthesis of these molecules require iitrogen.

Deficiency symptoms:

Absence or low supply of nitrogen develops the following symptoms.

1. Leaves turn pale yellow due to loss in chlorophyll content called chlorosis.
2. Process of cell-division and cell enlargment are inhibited.
3. Rate of respiration is affected.
4. In certain plants veins turn purple or red due to the development of Anthocyanin pigment e.g. tomato and apple leaves.
5. Plant growth remains stunted and lateral buds remain dormant, as a result cereals do not show characteristic tillering.
6. Prolonged dormancy and early senescence including leaf falls.

ii) Phosphorous (P):

Plants absorb phosphorous in the form of soluble phosphates such as H_3PO_4 and HPO_4. It is present abundantly in the growing and storage organs such as fruits and seeds. It promotes healthy root growth and fruit ripening by helping translocation of carbohydrates.

It is an essential element involved in the formation of cell-membrane as phospholipids, nucleic acid, co-enzyme (NAD and NADP) and organic molecules such as ATP and other phosphorylated products. It plays an important role in the energy transfer reaction in oxidation-reduction processes.

Deficiency symptoms:

In the case of phosphorous deficiency a few symptoms resemble that of nitrogen deficiency, like premature leaf fall and development of purple red anthocyanin pigment. Deficiency of phosphorous also shows some other symptoms.

1. Cambial activity is checked.
2. Tillering of crop plant is reduced.
3. Dormancy is prolonged.
4. Growth is retarded and dead necrotic patches appear on leaves, petioles and fruits.
5. Variable colours develop e.g. plate green in ***Pisum***, olive green in ***Phaseolus***.
6. Causes accumulation of carbohydrates.
7. Thickening of tracheal cells are reduced and phloem differentiation becomes incomplete.

iii) Potassium (K):

Potassium is widely distributed in soil minerals. It is strongly fixed in soil, therefore, found in less available form. Exchangeable potassium appears to be readily available to the plants.

The best known function of potassium is its role in stomatal opening and closing. It is found in highest concentration in the meristematic regions of plant. It is an essential activator for enzymes involved in the synthesis of certain peptide bonds and carbohydrate metabolism.

Deficiency symptoms:

The deficiency symptoms vary with the extent of the shortage of the element. In acute deficiency:

1. The colour of leaf may turn into dull or bluish green.
2. An irregular chlorosis occurs first, which is followed by the development of necrotic areas of the tip and margin of the leaf.
3 Plant is stunted in growth with a pronounced shortening of internodes and reduced production of grains.
4. Lamina of broad leaved plants curl backward towards the under surface or roll forward towards the upper surface parallel with midrib.

iv) Magnesium (Mg):

Magnesium is present in the soil in water-soluble, exchangeable and fixed form and is present in primary minerals. It is found as carbonates similar to that of calcium and held in soil as exchangeable base.

It is a constituent of chlorophyll and therefore essential for the formation of green pigment. It acts as phosphorous carrier in plant, particularly in connection with the formation of seeds of high oil contents which contains compound lecithin. It is readily mobile and when its deficiency occurs, it is apparently transferred from older to young tissues where it can be reutilized in growth processes.

Magnesium is essential for the synthesis of fats and metabolisms of carbohydrates and phosphorous.

Deficiency symptoms:

1. Deficiency symptoms develop first on the older leaves and then proceed systematically towards younger leaves.
2. Chlorosis occurs.
3. Severly affected leaves may wither and shed or absciss without the withering stage. Defoliation may be quite severe.
4. Leaves, sometimes, develop necrotic spots.

> Some kinds of plants have specific nutritional requirements that are not shared by others, e.g silica, essential for the growth of many grasses, cobalt-necessary for the growth of nitrogen fixing bacteria-essential for the growth of nodules and legumes. Nickel, essential for soyabean. Sodium, important in maintaining osmotic and ionic balances, required by some desert and salt marsh species.

12.5 HETEROTROPHIC AND SPECIAL MODE OF NUTRITION IN PLANT

Plants which are not capable of manufacturing their own organic molecules entirely or partially depend for these organic molecular requirements on outside sources and are called **heterotrophic** plants.

Among heterotrophic plants those which depend on living plants and animals for their nutritional requirements are known as ***parasites***. Parasites which depend for their nutrition entirely on other living organisms are known as ***obligate*** or ***total parasites*** and those which depend for these requirements partially on other living organisms are called ***facultative*** or ***partial parasites*** or ***facultative parasites***. On the other hand, the plants which depend on dead or rotten organic remains of plants and animals are called ***saprophytes***. Like parasite, the plants which depend entirely on dead organic matter are known as ***total saprophytes*** and those which depend for these requirements partially on dead organic matter are called ***partial saprophytes***.

12.5.1 Parasitic plants:

For obtaining their food requirements parasitic plants develop haustoria, which penetrate into host tissues for absorbing nutrients requirements.

Parasitic angiosperm

Parasitic angiosperms are broadly classified into:

i) Partial stem parasite.

ii) Total stem parasite.

iii) Partial root parasite.

iv) Total root parasite.

i) Partial stem parasite: *Loranthus* is a partial stem parasite. It has well developed thick green leaves, a somewhat woody stem and elaborated haustorial system. It can manufacture some of its food with the help of nutrients and water absorbed from the host plants through haustoria. The seeds get stuck up to the stem of the host plant and germinate, sending its haustoria in the tissue of the host. *Loranthus* is commonly found on shrubs, roseaceous trees, *Bauhinia* and mango, often causes serious damage. Other examples of partial stem parasites are:

Viscum — produce haustorial branches for an internal sucking system.

Cassytha filiformis — found in tropics, a leaf less, wiry stem, send the haustoria that penetrate in the stem to develop connection with vascular tissue of host plants.

ii) Total stem parasite: The plants like *Cuscuta* (Amer-bail) is a common parasite which attacks stems of many herbs, shrubs and trees. They send haustoria inside the tissue of host. The xylem of parasite comes in contact with the xylem of host and phloem of parasite to phloem of host. Through xylem it sucks the water and nutrients and through phloem prepared organic food material. The host plant eventually dies off due to exhaustion.

iii) Partial root parasite: The example or types of this category are rare. The sandal wood tree is an important example. Its seedling can grow for a year but not so independently. Within a year the sucking roots of plant attack the root of neighbouring trees and from them nutrients are absorbed.

iv) Total root parasite: They suck their nutritional requirements from the roots of host e.g. *Orobanche*, attacks the roots of plants belonging to the families Cruciferae and Solanaceae. *Cistanche* parasitizes on the roots of *Calatropis*. *Striga* is found as parasite on the roots of sugarcane, commonly found on Sorghum or Jowar crop.

12.5.2 Saprophytes:

Plants which break up complex dead organic food material into simple compound and use them for their growth and development are saprophytes. There are some examples found among flowering plants like *Neotia* (bird's nest or orchid) of ... i Monotrapa (Indian pipe), in these cases the roots of the plant form a mycorrhizal ...ociation with fungal mycelium to help in the absorption process.

For centuries, farmers have rotated crops to take advantages of such relationships. They observed that if grew clover or alfalfa one, the following year's crop of wheat grow more luxuriantly. Likewise, rice farmers have encouraged the growth of water in their flooded rice paddies because cyanobacteria living symbiotically in the ferns fix atmospheric nitrogen and enrich the growth of rice plants. In water logged bogs, where soils tend to be too acidic for bacteria to survive, insectivorous plants such as the venous fly trap and the **pitcher plant**, have evolved the ability to gain needed nitrogen by trapping and digesting insects.

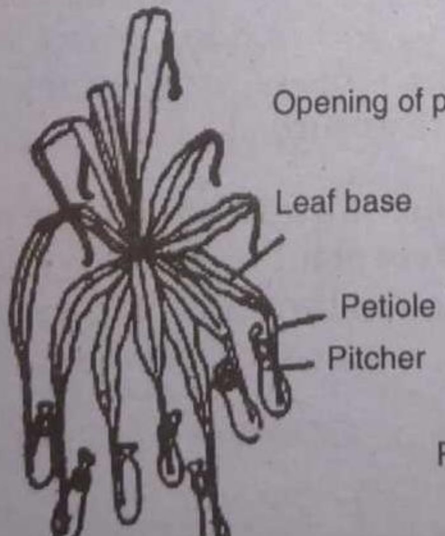
.5.3 Carnivorous plants (Insectivorous plants):

There are plants which have insects and small birds as their prey. J.D. Hooker ...ggested that the digestion of carnivorous plants is like that of animals. Infact enzymes ...reted by these plants are similar to those found in human stomach e.g. Pepsin.

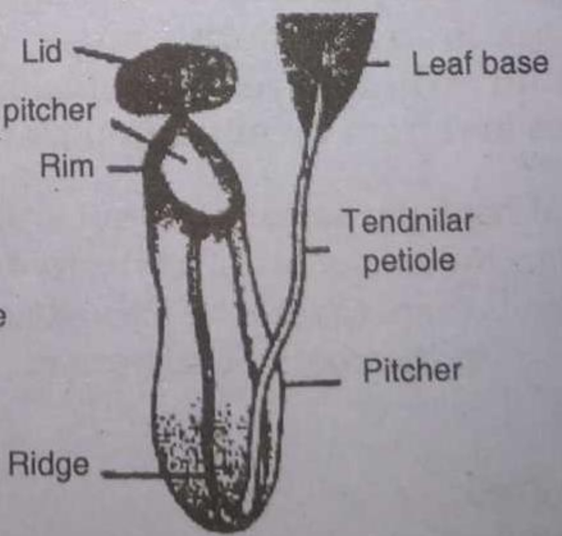
Partially autotrophic plants and partially heterotrophic plants are carnivorous ...ich possess the green pigments and can manufacture carbohydrates but are not ...pable of synthesizing nitrogenous compounds and proteins. For their nitrogen or ...oteins requirement carnivorous plants have to depend on insects which they ...ch and digest by specific devices developed in them.

These plants commonly grow in areas where nitrogen is deficient due to favourable atmosphere for nitrifying bacteria but favourable atmosphere for nitrifying bacteria. They have to depend on insects for their nitrogen and protein ...quirements. Some common examples are:

i) **Pitcher plant:** It has a modified leaf of pitcher shape. Common ...ample are *Nepenthes, Sarracenia, Cephalotus, Heliamphora, Darlingtonia.* Common ...cher plant is *Sarracenia pupurea* or yellow pitcher plant *Sarracenia flava.*



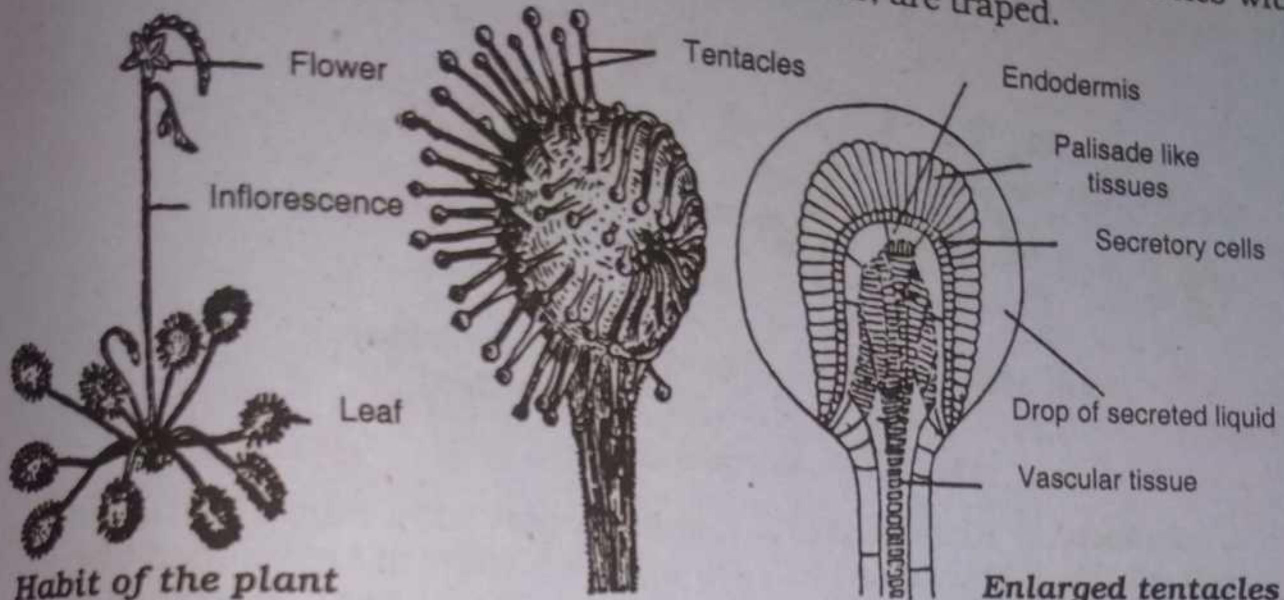
Habit of the plant



An enlarged portion of leaf

Fig. 12.1 Nepenthes khasiana

ii) ***Drosera intermedia* or Sundew:** A plant with loose and about half a dozen prostrate radiating leaves. The tiny leaves bear hair like tentacles with glands at its tip. The insect, attracted by plant odour, are traped.



Habit of the plant

Magnified terminal region of leaf

Enlarged tentacles showing internal organization

Fig.12.2 Drosera or sundew

iii) ***Dionaea muscipula* or Venus fly trap:** It is most well known of all carnivorous plants. Charles Darwin called it "the most wonderful plant in the world".

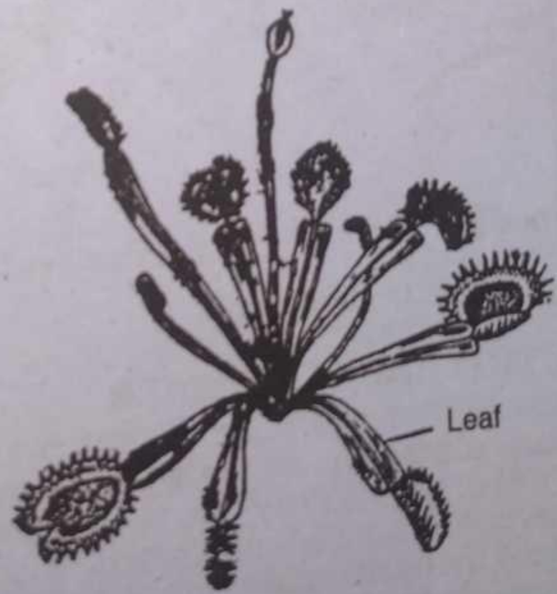


Fig. 12.3
Dionaea — *Habit of pla*...

It has a rosette of prostrate radiating leaves with the inflorescence in the centre. The junction of petiole and lamina is constricted upto the mid-rib, the petiole is winged and lamina has two halves, with mid-rib in centre. Each half has 12-20 teeth. The teeth of one half can interlock with the teeth of the other half. In the centre of the dorsal surface of lamina are numerous secretory glands, three hairs projecting outwards which are sensitive to touch.

be achieved by adding fluoride in drinking water or food like milk, or by taking fluoride tablets and using fluoride tooth paste.

Tongue:

The tongue is a muscular fleshy structure lying in the floor of the oral cavity having taste buds and tongue papillae. It is attached posteriorly but free anteriorly. It functions as the spoon and mixes the masticated food with saliva and afterwards helps in swallowing. It also helps in sucking and tasting the food.

Salivary Glands and Saliva:

The oral cavity has three pairs of salivary glands, which produce about 1.5 dm^3 of saliva each day. The ***Parotid*** glands lie at the base of the pinnae, ***sublingual*** glands at the base of the tongue and the ***Submandibular*** glands at the base of the lower jaw.

The saliva is a watery secretion containing 95% water, some mucus, amylase and lysozyme enzymes. The mucus moistens and lubricates the food for comfortable swallowing. The salivary amylase begins the digestion of starch, first to dextrins (shorter poly saccharides) and then to disaccharide maltose. Lysozyme destroys the oral cavity pathogenic bacteria. Ultimately the semi solid, partially digested food particles stick together by mucus and molded into a rounded mass **bolus** by the tongue which then pushes it into the pharynx.

12.10.2 Pharynx and Swallowing:

It is the posterior narrow part of the oral cavity which contains the openings of the oesophagus and glottis in addition to the openings of the internal nostrils and the eustachian tubes.

Without the palate we could either breathe or swallow the food, but not both.

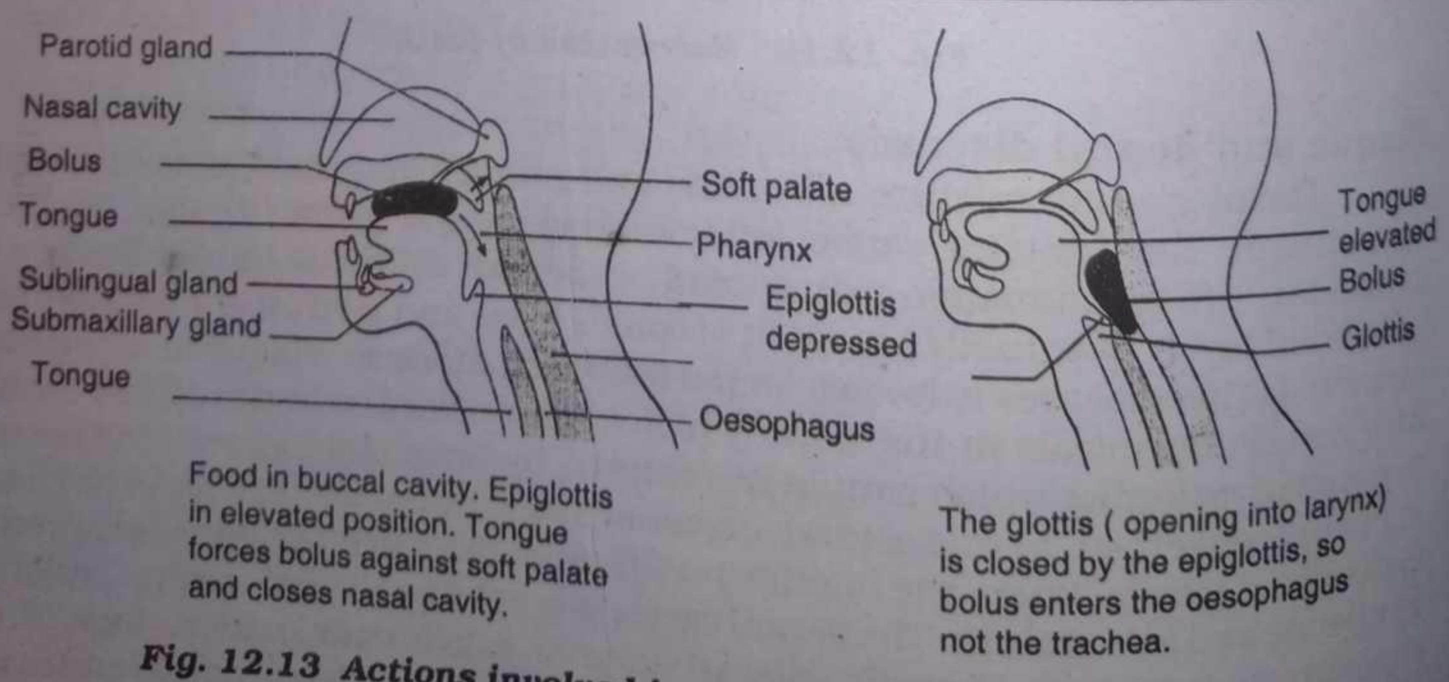


Fig. 12.13 Actions involved in the swallowing of food in humans

The swallowing is initially a voluntary action but afterwards it continues as involuntary action. The soft palate helps in swallowing during which the elastic cartilagenous flap **epiglottis** is pushed flat over the glottis by the upward movement of the larynx, so that no food enters the wind pipe. However when accidentally some thing other than gases, comes in between the epiglottis and glottis, a powerful coughing reflex expels it out and throws it back into the mouth cavity. The swallowed food in the form of bolus passes down into the oesophagus.

12.10.3 Oesophagus:

This is a narrow muscular tube containing mucous glands about 25 cm long running through the thoracic cavity. It conveys the food and fluids by peristalsis from pharynx to the stomach.

Peristalsis:

The basic propulsive movement of the gastro-intestinal tract is peristalsis. These are alternate rhythmic contractions and relaxations of the gut wall. The usual stimulus for peristalsis is distension.

To swallow water peristaltic movements are required although it can flow down easily.

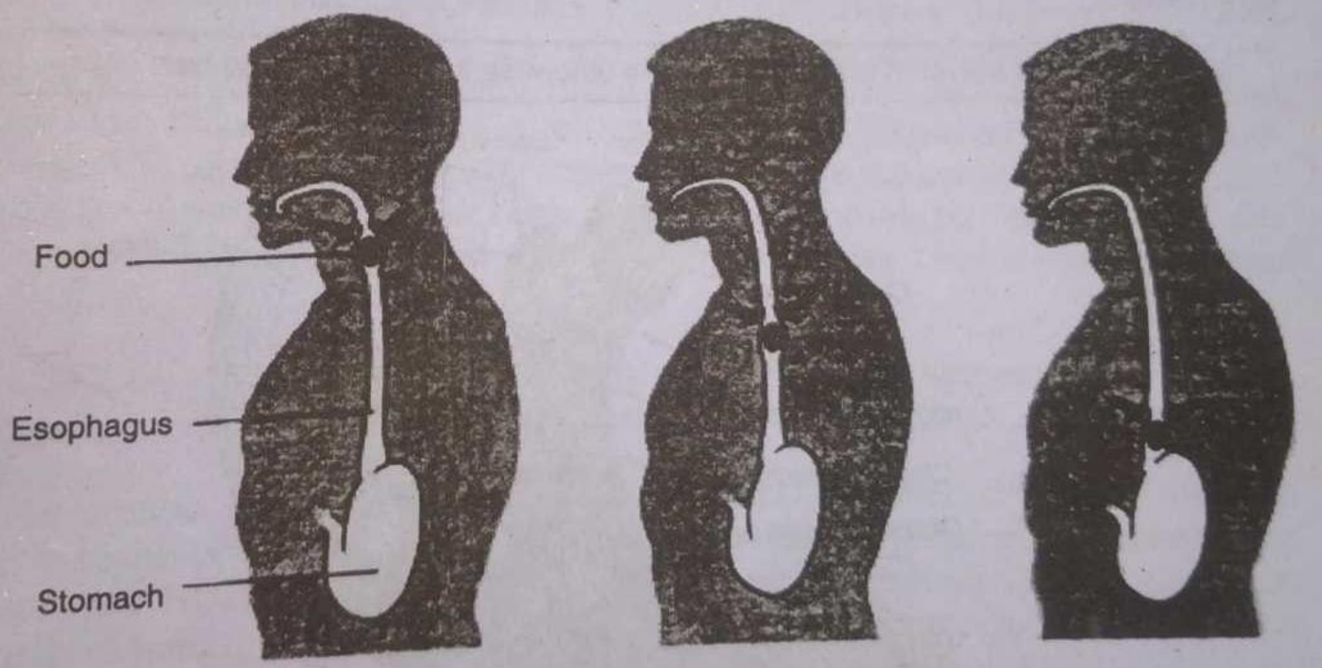


Fig. 12.14 Movement of food through the alimentary canal

Antiperistalsis:

In the early stages of excessive gastro-intestinal irritation or over distension, antiperistalsis begins to occur, often minutes before vomiting appears. When the abdominal muscles contract, the stomach is squeezed. Finally the gastro-oesophageal sphincter relaxes allowing the expulsion of the gastric content upward through the oesophagus in the form of vomiting.

12.10.3 Stomach:

The stomach is a distensible muscular bag lying below the diaphragm on the left side of the abdominal cavity. It performs three functions: storage of food, mechanical digestion by peristalsis and the chemical digestion of food by enzymes, which is reduced to a creamy paste called ***chyme***.

The stomach has three regions. Anterior ***cardiac region*** having mucous glands, which joins the oesophagus through a cardiac sphincter. The middle region is the ***fundus*** which is the main part and has gastric glands. These gastric glands contain three types of cells; Mucus secreting cells, Zymogen cells secreting pepsinogen and Oxyntic cells which secrete dilute hydrochloric acid having a pH of 1.5 to 2.5. This collective secretion is known as ***gastric juice***. The mucus lubricates and protects the stomach lining from self digestion by pepsin. The HCl kills the bacteria and activates the inactive enzyme pepsinogen into ***pepsin*** which acts upon proteins and convert them into short chain polypeptides, peptones. The posterior part is the terminal narrow ***pyloric region*** which like the cardiac region produces mucus. It opens into the duodenum through pyloric sphincter or pylorus which acts as a valve and serves to retain food in the stomach for about four hours. Periodic relaxation of pyloric sphincter releases small quantities of chyme into duodenum.

Pepsin is secreted in an inactive state otherwise it would digest its own cells.

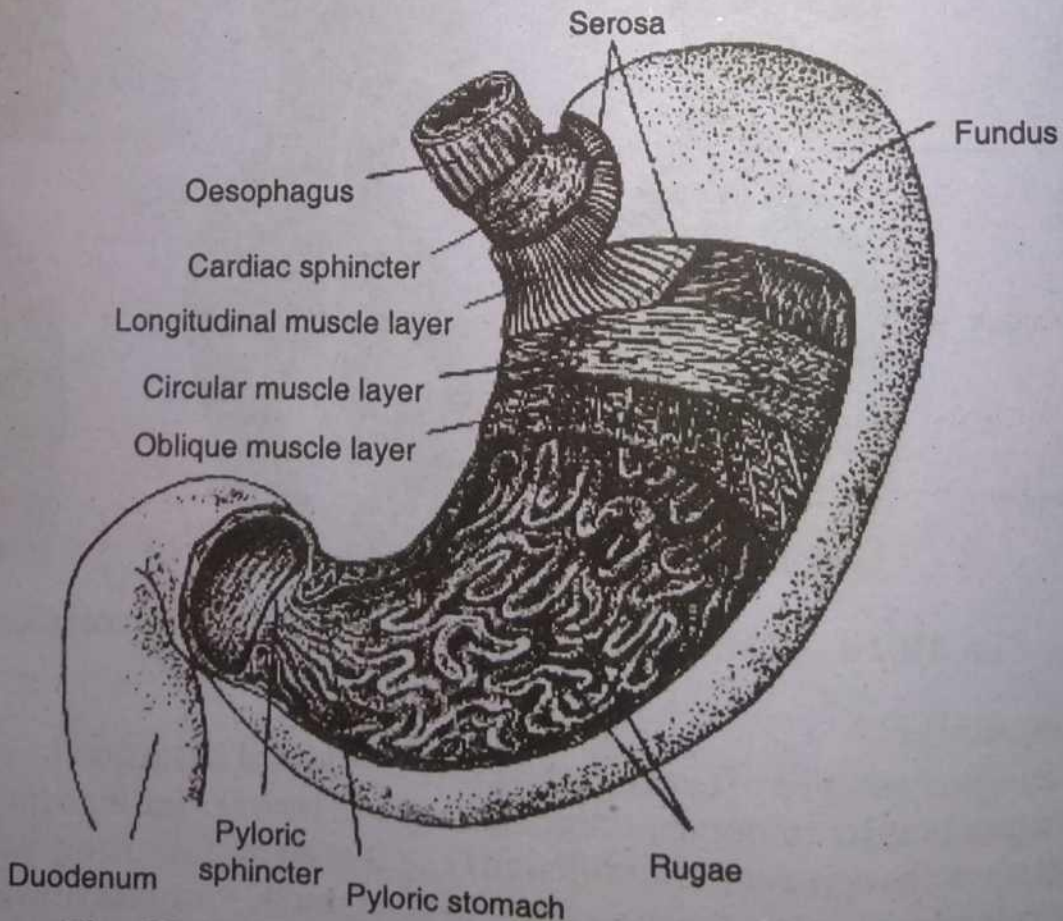


Fig. 12.15 Stomach, muscle layers and interior

In infants, another proteolytic enzyme **renin** is secreted which curdles the milk and converts soluble milk proteins (caseinogen) into insoluble proteins (casein) in the presence of calcium ions. This is then digested by pepsin.

> Stomach also produces a hormone **gastrin** in the presence of partially digested proteins which activates the gastric glands to produce gastric juices. The secretions come immediately into contact with that portion of the stored food lying against the mucosal surface of the stomach. When stomach is filled, weak peristaltic waves also called mixing waves move along the stomach wall once every 20 seconds. As these waves move down the stomach, they not only cause secretions to mix with the stored food but also provide weak propulsion to move these mixed contents within the cavity of stomach.

12.10.4 Small Intestine:

Next to the stomach is the small intestine, about 6 metres long and 2.5 cm wide. Its coiled loops fill most of the abdominal cavity. There are three divisions of small intestine, duodenum, jejunum and ileum.

Duodenum:

Duodenum begins just after the pyloric stomach. It is about 30 cm long and runs parallel to the stomach. It receives a common bile duct and a pancreatic duct opening by a common aperture. The chyme on entering the duodenum meets the bile from the liver and the pancreatic juice from the pancreas. Bile is yellow in colour but on exposure to air it changes to green. It contains water, bile salts and bile pigments but no enzyme. The bile salts (sodium bicarbonate) neutralize the acid of the gastric juice and make the chyme alkaline. The other salts emulsify the fats into small fat globules which can mix with water to form an emulsion. Fats can be digested only when emulsified.

The bile pigments ***bilirubin*** (red) and ***biliverdin*** (green) are excretory products formed by the breakdown of haemoglobin of worn out R.B.Cs in the liver.

Pancreatic juice is secreted by the pancreas, under the stimulation of another hormone ***secretin*** produced by the duodenum. Secretin is produced under the stimulus of HCl carried with chyme. The pancreatic juice is a watery, colourless alkaline fluid having four enzymes, trypsin (protease), chymotrypsin, amylase and lipase.

Trypsin is secreted as an inactive precursor **trypsinogen** which is activated by an enzyme ***enterokinase*** produced by the duodenum. It acts upon the polypeptides and proteins and convert them into polypeptides. ***chymotrypsin*** converts casein (milk proteins) into short chain amino acids. ***Amylase*** converts starch and glycogen into maltose and **lipase** converts emulsified fats into fatty acids and glycerol, which are the soluble end products of fat. Thus the digestion of fat is completed in the duodenum.

Duodenum passes into ***jejunum*** which is about 2.4 metres long. The digestion of food is completed within the jejunum by a number of enzymes such as maltase, sucrase, lactase and peptidase. Here the final hydrolysis of disaccharides, tri and dipeptides occur. The end products are monosaccharides and amino acids respectively which are liberated into the lumen of the small intestine. Also present in the small intestine is nucleotidase which converts nucleotides to nucleosides.

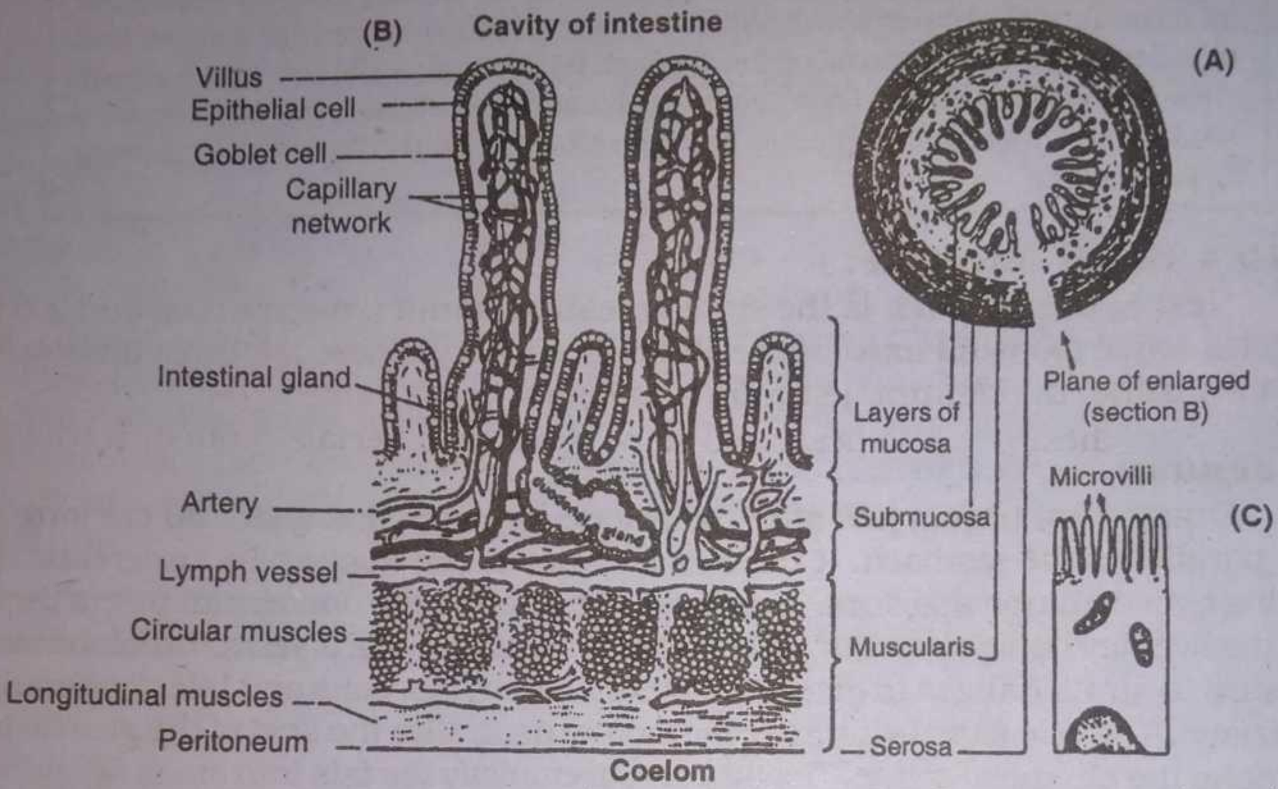


Fig. 12.16 Structure of small intestine (duodenum)

Jejunum passes into ***ileum*** which is about 3.6 metres long. It receives much diluted food ***chyle*** containing digested food in the true solution form. The inner wall of the small intestine contains circular folds with finger-like microscopic projections called ***villi***, whose walls are richly supplied with blood capillaries and lymph vessels called ***lacteals*** and contain smooth muscles. They are able to contract and relax, constantly thus bringing themselves into close contact with the food in the small intestine. This increases the absorptive surface area. Each villus is lined by epithelial cells having microvilli on their free surface. The monosaccharides and amino acids are absorbed into the blood capillaries either by diffusion or active transport, while the fatty acids and glycerol enter the epithelial cells of the villi. Here they are reconverted into simple fats (triglycerides) which then enter the lacteals and pass into the blood stream. The blood capillaries converge to form the hepatic portal vein which delivers the absorbed food to the liver where it is stored and is distributed to all the cells of the body.

Active transport is employed in the absorption of digested food as their concentration is lower than the blood.

12.10.5 Large Intestine:

Small intestine opens into large intestine. It has a large diameter about 6.5 cm. It is divided into a short caecum, a long colon and a terminal rectum. The ***caecum*** is placed in the lower right side of the abdominal cavity and gives off a blind tube of about 18 cm long from its lower portion known as ***vermiform appendix*** which is a vestigial organ. It is of great significance in herbivores lodging symbiotic bacteria which help in the digestion of cellulose. The **colon** is the longest part and has three regions, ***ascending colon, transverse colon*** and ***descending colon. Inorganic*** salts, vitamins and water are absorbed in the colon.

The ***rectum*** is the last portion of the large intestine . The undigested and unabsorbed food material passes down into the colon and rectum where water and inorganic nutrients are absorbed while some metabolic waste and inorganic substances notably calcium in excess in the body are excreted as salts, along with the faeces, which are stored in the rectum for some time. When the rectum is full, the faeces pass out through the process known as egestion. Many symbiotic bacteria present in the large intestine synthesize amino acids and some vitamins especially vitamin K which are absorbed into the blood stream.

12.10.6 Liver and Pancreas:

Liver and pancreas are two important glands which are closely related to digestion. Liver is the largest gland as well as the largest organ of the body. It is reddish brown in colour and lies behind the diaphragm more towards the right side. It has two main lobes, a right and a left lobe joined by a ligament. The left lobe is further divided into two lobes.

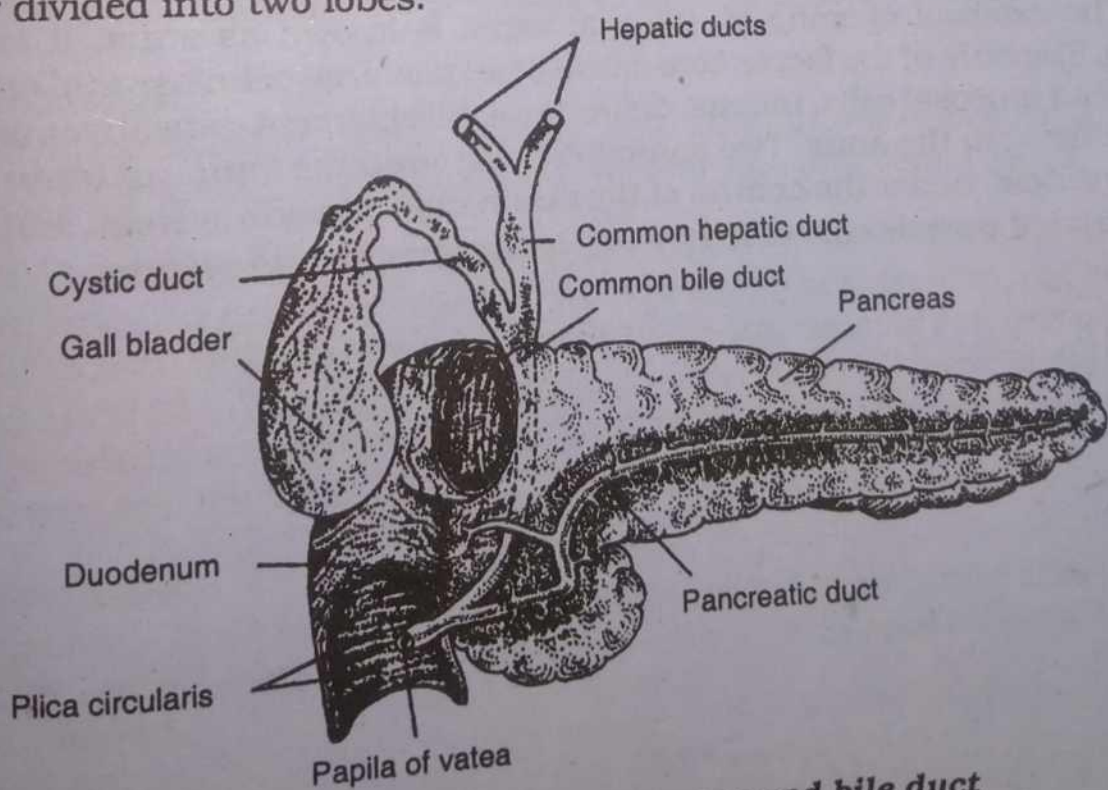


Fig. 12.17 Man — Pancreas and bile duct

A pear shaped gall bladder lies on the under surface of the liver. It stores bile which is secreted by the liver cells. The bile is collected by two hepatic ducts which join the cystic duct coming from the gall bladder forming a common bile duct which joins the pancreatic duct and opens into duodenum.

Liver is a metabolic factory, detoxification center and storage organ. One of its functions is to maintain an appropriate quantity of level of nutrients in the body. It is performed in three ways. Surplus amount of glucose is deposited in the liver cells after every meal. Here the glucose is transformed into glycogen in the presence of insulin, a hormone released from the pancreas. The glycogen can later be hydrolized through glucagon for energy to meet the body's energy requirements. The amino acids are also stored after deamination (removal of NH_2 group), which forms the urea. The liver also processes fatty acids and stores the products as ketone bodies which later are released as nutrients for active muscles. Liver also prevents certain poisons from harming the body by breaking them into harmless compounds. In addition to these functions liver stores vitamins, produces necessary substances for coagulation of blood. It keeps the composition of blood fairly constant. It excretes out the bile pigments and other waste products.

The pancreas lies behind the stomach horizontally within the curve of the duodenum. It is exocrine as well as endocrine in function. The exocrine part produces pancreatic juice and the endocrine part produces insulin and glucagon hormones.

12.10.7 Anus and Egestion:

The external opening of the anal canal is known as anus. It is used in egestion. The bulk of the faeces consists of dead bacteria, cellulose and other plant fibres, dead mucosal cells, mucus, cholesterol, bile pigment derivatives and water, pass out through the anus. Two sphincters surround the anus, an internal one of smooth muscle, under the control of the autonomic nervous system, and an outer one of striated muscle controlled by the voluntary nervous system.

Table 12.1 Summary of digestive secretions and their action.

Secretion	Enzymes	Site of action	Optimum pH	Substrate	Products
Saliva (from salivary glands)	Salivary amylase	Buccal cavity	6.5–7.5	Amylose in starch	Maltose
Gastric juice (from stomach mucosa)	(Pro) rennin (in young) Pepsin (ogen) Hydrochloric acid (not an enzyme)	Stomach Stomach Stomach	2.00 2.00 —	Caseinogen in milk Proteins Pepsinogen Nucleoproteins	Casein Peptides Pepsin Nucleic acid and protein
Membrane-bound enzymes in small intestine Exopeptidases	Amylasae Maltase Lactase Sucrase Aminopeptidase Dipeptidase	Microvilli of brush border of epithelial mucosa of small intestine	8.5 8.5 8.5 8.5 8.5 8.5	Amylose Maltose Lactose Sucrose Peptides and dipeptides	Maltose Glucose Glucose + galactose Glucose + fructose Amino acids Amino acids
Intestinal juice	Nucleotidase Enterokinase	Small intestine Small intestine	8.5 8.5	Nucleotides Trypsinogen	Nucleosides Trypsin
Pancreatic juice (from pancreas) Endopeptidases* Exopeptidase*	Amylase Trypsin (ogen) Elastase Chymotrypsin (ogen) Carboxypeptidase Lipase Nuclease Bile salts (not enzymes)	Small intestine Small intestine Small intestine Small intestine Small intestine Small intestine Small intestine Small intestine	7.00 7.00 7.00 7.00 7.00 7.00 7.00 7.00	Amylose Proteins Chymotrypsinogen Proteins Proteins Peptides Fats Nucleic acid Fats	Maltose Peptides Chymotrypsin Peptides Amino acids Amino acids Fatty acids + glycerol Nucleotides Fat droplets

* Exopaptidases split off terminal amino acids from protiens (polypeptides).

* Endopaptidases break bonds between amino acids within proteins thus producing smaller peptides.

12.11 DISORDERS OF THE GASTRO-INTESTINAL TRACT

(1) Diarrhoea:

Diarrhoea or loose motions results from rapid movement of faecal matter through the large intestine. Diarrhoea may occur due to several causes.

Entritis caused by a virus or by bacteria in the intestinal tract. Due to infection the mucosa becomes irritated. The motility of the intestinal wall increases many folds. Sometimes ***cholera*** may cause diarrhoea, causing extreme quantities of bicarbonate ions to be secreted into the intestinal tract along with the massive amounts of sodium ions and water, leading to death. ***Psychogenic Diarrhoea*** is caused by nervous tension.

(2) Dysentary:

Dysentary is an acute inflammation of the large intestine characterised by diarrhoea with blood and mucus in the stool. It is caused by bacillary or amoebic infection.

(3) Constipation:

Constipation means slow movement of faeces through the large intestine and is often associated with large quantities of dry hard faeces in the descending colon which accumulates because of the long time available for absorption of fluid.

A frequent cause of constipation is irregular bowel habits that have developed through a life time of inhibition of normal defecation reflexes.

(4) Piles:

Piles are also known as ***haemorrhoids***. These are dilated veins occurring in relation to the anus. Such haemorrhoids may be external or internal to the anal opening. The external piles are covered by skin while the internal piles lie beneath the anal mucous membrane.

The most common cause of piles is the constipation. The pressure exerted by the persons to defecate stretches the skin along with the veins resulting in their dilations forming haemorrhoids. Piles can be avoided by regular habit of defecation and the use of fibre diet, which is coarse in texture and makes it easier to pass out.

(5) Dyspepsia:

Dyspepsia is commonly known as epigastric discomfort following meals. It may be due to peptic ulcer. This is characterized by heart-burn, flatulance, by the anorexia, nausea and vomiting with or without abdominal pain.

Some persons have persistent dyspepsia for which no cause can be found. This is non-ulcer or functional dyspepsia caused by disturbances in the motor function of the alimentary tract.

(6) Peptic ulcer:

A peptic ulcer is a damaged area of the mucosa caused by the digestive action of gastric juice, in the first few centimeters of the duodenum. In addition, peptic ulcers frequently occur in the stomach or more rarely in the lower end of the oesophagus where stomach juices frequently reflux.

It is believed that duodenal ulcers are caused by excessive secretion of acid and pepsin by the gastric glands. The development of duodenal peptic ulcer is strongly hereditary. In addition to hereditary factors psychogenic factors that cause stress, anxiety seem to play a role in peptic ulceration.

(7) Food poisoning:

Food poisoning or gastro-enteritis can be due to many causes like the infection by virus, bacteria, protozoa or non infective by some allergy. It presents with vomiting, diarrhoea or both, usually within 48 hours of consumption of the contaminated food or drink.

Salmonella species are very common causes of food poisoning. The domestic fowl is the commonest source of infection which may be contracted from inadequately defrosted and uncooked chicken or from under cooked or raw eggs.

(8) Malnutrition:

When an organism is deficient in or receives excess of one or more nutrients over a long period of time is said to have malnutrition. The deficiency is known as under-nutrition and the excess, over-nutrition. Under-nutrition is the most common problem of underdeveloped countries. Extreme protein deficiency causes kwashiorker disease resulting in edema. Whereas obesity with heart ailment and reduced life expectancy are the symptoms of over nutrition which is more common in developed countries.

(9) Over weight and obesity:

Obesity is the most common nutritional disorder. Obesity may be defined as a condition in which there is an excessive amount of body fat. Excess fat accumulates because there is imbalance between energy intake and expenditure. Obesity is most prevalent in middle age but can occur at any stage of life. It can be a family tendency.

Over weight is associated with an increased rate of mortality at all ages. A substantial reduction of the body weight of obese people is alone sufficient to reduce the death rate.

(10) Anorexia nervosa:

Anorexia nervosa is loss of apetite for food, a psychological condition usually seen in girls and young women, characterized by severe and prolonged inability or refusal to eat. Some times accompanied by spontaneous or induced vomiting.

(11) Bulimia nervosa:

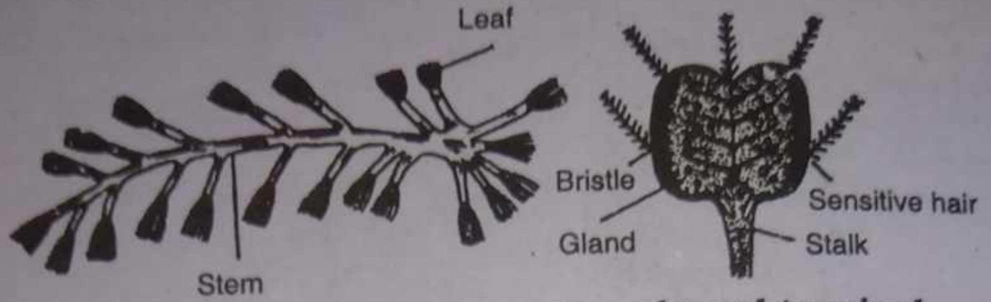
It is almost exclusively confined to women and the age of onest is slightly older than for anorexia. The symptoms of bulimia nervosa are recurrent bouts of binge eating, lack of self-control over eating during binges. The binges occur at least twice weekly and involve rich foods such as cakes, chocolates and dairy products. It is an exclusively abnormality found in the adult women.

12.12 PARASITIC NUTRITION

Parasitism is an association between two living organisms of different species in which one partner is benefited and the other is at loss. The benefited partner is known as ***parasite*** and the partner at loss is called the ***host***.

The parasite obtains food either through absorptive or ingestive method from the host. A successful parasite is able to live with the host without causing it any harm. Parasites which live on the outer surface of the host are called ***ectoparasites***. Those that live within a host are ***endoparasites***. The parasites may be ***obligatory***

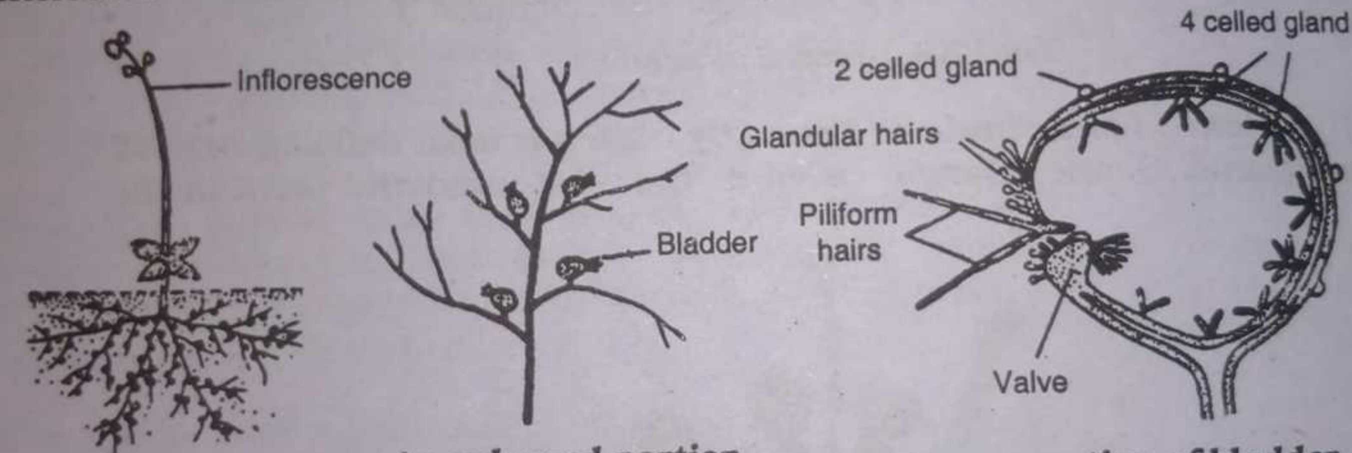
iv) **Aldrovanda (water fly trap):** A rootless aquatic plant with floating stem. It has rosettes of modified leaves, which have two lobed mobile lamina having teeth at the margin and sensitive jointed hairs and stalked gland on the surface.



Habit of the plant *An enlarged terminal portion of leaf*

Fig. 12.4 Aldrovanda

v) **Utricularia or Bladder Wort:** Rootless plant have much branched slender stem. Leaves are also much divided, some of the leaflets are developed into bladder like traps of about 1/16 to 1/8 inches in diameter. The trapes have trapdoor enterances which allow small aquitic animals to get in with no return.



Habit of the plant *An enlarged portion* *A cross section of bladder*

Fig. 12.5 Utricularia

12.6 HETEROTROPHIC NUTRITION IN ANIMALS

The heterotrophic nutrition is that nutrition in which the organisms are dependent upon other organisms, plants or animals for complex ready made organic food. Their carbon source is organic. They use it as a source of energy for their vital activities, building materials for repair, growth and to get (procure) vitamins, that cannot be synthesized in these organisms. All animals, fungi and the majority of bacteria fall into this category and are known as ***heterotrophs.***

The manner in which heterotrophs procure and take in food varies considerably, but the way in which it is processed into a utilisable form within the body is similar. It involves digestion, reducing complex food into soluble molecules and absorption by which soluble food molecules are absorbed into the body. This particular type of nutrition is known as ***holozoic*** and is found in animals. The other modes of heterotrophic nutrition are ***saprotrophic*** and ***parasitic.***

The organisms which feed on dead or decaying organic matter of plants and animals are called ***saprotrophs***. Many fungi and bacteria are saprotrophs.

Some animals feed upon fragments of decomposing material (detritus) and contribute to the process of break down. They are called ***detritivores*** (earth worm). Some animals hunt, capture and kill their prey to eat. These are known as ***predators*** (lion). Some animals feed on plants, primary producers and are known as ***herbivores*** (cow). Some feed on other animals are known as ***carnivores*** (dog) and those that eat meat as well as vegetable matter are termed ***omnivores*** (crow and man).

Some animals are called ***filter feeders*** such as sponges. If the food is ingested in liquid form, they are known as ***fluid feeders*** (honey bee). Even the size of the food varies in different animals. If they take in small food particles, they are known as ***microphagous feeders***. When they take food in the form of large pieces, are termed as ***macrophagous feeders***.

12.7 HOLOZOIC NUTRITION

The nutrition in which complex, non-diffusible food is taken in and digested

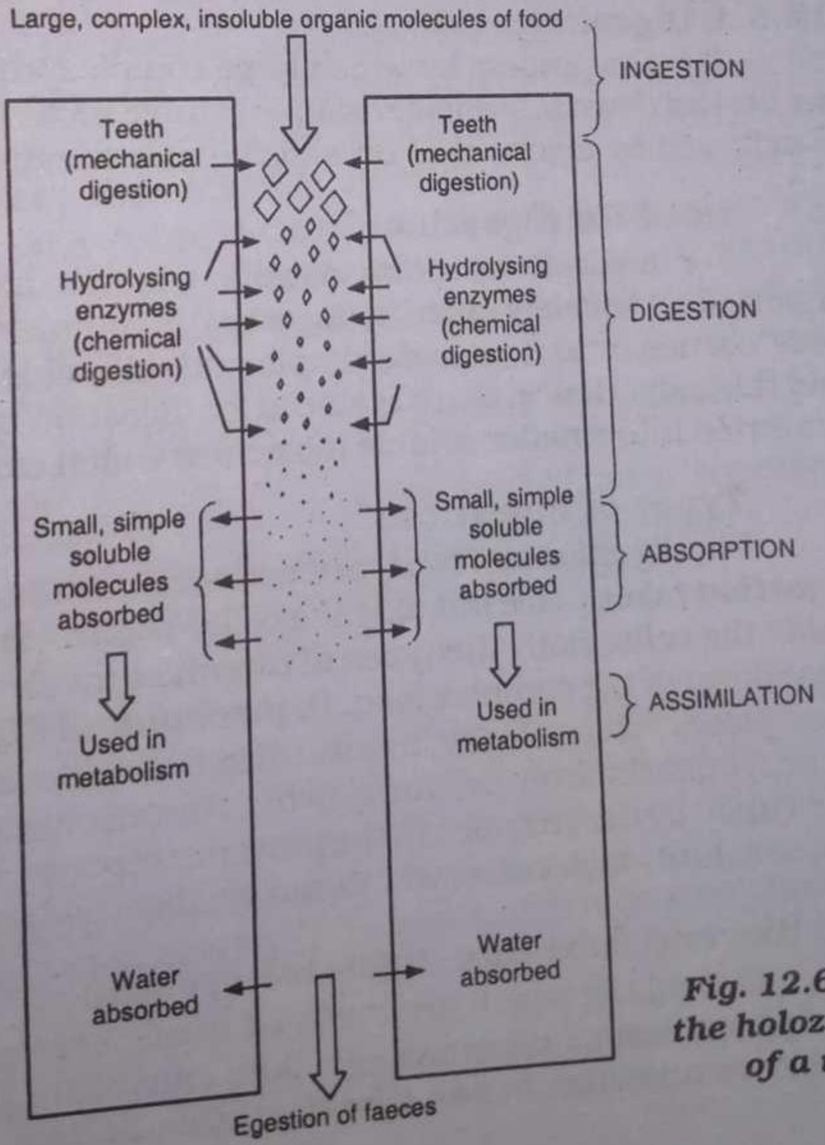


Fig. 12.6 Stages in the holozoic nutrition of a mammal

into smaller diffusible molecules which can be absorbed and assimilated is known as holozoic nutrition. It is found in free living animals which have a specialized digestive tract in which various processes occur.

The holozoic nutrition is achieved by the following processes.

1. **Ingestion** — The taking in of complex organic food.
2. **Digestion** — The breakdown of large complex insoluble organic molecules.
3. **Absorption** — The uptake of soluble molecules from the digestive region, across a membrane into the body cells.
4. **Assimilation** — The utilization of the absorbed food molecules by the body to provide energy or materials for tissue building.
5. **Egestion** — The elimination of the undigested food from the body.

12.8 DIGESTION AND ABSORPTION

12.8.1 Digestion:

It is the process by which large complex insoluble organic food substances are broken down into smaller simple soluble molecules by the help of enzymes. This is achieved by mechanical breakdown and enzymatic hydrolysis.

1. Need for digestion:

For holozoic nutrition digestion is the most important process, as the organic food which is taken in (ingested) is complex and cannot be diffused into the body tissues until it is made simple and diffusible which can readily be absorbed into the body. Hence, there is a need for digestion by which large molecules can be converted into smaller soluble molecules which can be easily diffused.

2. Types of digestion:

The digestion is of two types, extracellular and intracellular. The ***extracellular digestion*** takes place out side the cells. The ***intracellular digestion*** takes place inside the cells. Both the types of digestion involve the mechanical and chemical breakdown of the complex food. In ***mechanical digestion***, the food is broken into small pieces mechanically, by churning or mastication. The ***chemical digestion*** is the enzymatic hydrolysis, during which the mechanically digested food particles are acted upon by the enzymes in the presence of water, modifying them chemically into simple soluble molecules; which can be absorbed readily within the digestive tract.

Sac like and tube like digestive system:

The organs which are involved in all these processes (ingestion, digestion, absorption, assimilation and egestion) constitute the digestive system. It may be sac-like or tube like. In ***sac-like digestive system***, there is only a single opening which is known as the mouth. The mouth opens into a large sac-like body cav which also functions as the digestive cavity. The food is partially digested here the help of digestive juices. The undigested food is egested through the mou Since it lacks the anal opening the digestive system is termed as incomplete.

In ***tube like digestive system*** the digestive cavity is separate from the bo cavity. It has both the openings, mouth and anus. The ingestion takes place throu the mouth and the egestion through the anus. Such digestive system is known complete digestive system. The tubular digestive system has an advantage over sac-like, that the food is completely digested within the digestive tract.

3. Ingestion:

As already mentioned earlier the ingestion is the initial process of holoz nutrition by which the food is taken in either directly by phagocytosis or through mouth. The phagocytosis is seen in protozoans like Amoeba, Paramecium etc., which the food is taken into, the food vacuole either through pseudopodia or throu ciliary action, where it is subjected to intracellular digestion.

In metazoans, the ingestion takes place through the mouth which is a perman opening of the digestive tract. In microphagous feeders such as filter feeders e Daphnia, the limbs with stiff bristles move forward to draw water containing suspend food particles towards themselves. The bristles filter off the food from this feedi current. When the limbs move backward, the food is propelled towards the mouth. Mytilus (common mussel) and other bivalves, the movement of cilia present on the gi causes a current of water to enter the body via an inhalent siphon and leave throug exhalent siphon. The water which enters contains the food particles, which g entangled in the mucus. This trapped food is then swept by cilia towards the mout

In macrophagous feeders, the ingestion is facilitated by tentacles or arms whi seize the prey or radula which scraps the algae or by some other means. In fluid feede the mouth parts are modified for piercing and sucking.

12.8.2 Absorption:

It is the post digestion process in which the digested soluble food substanc are absorbed directly into the body cells or through body fluids, blood and lymp In protozoans, the digested food is diffused into the cytoplasm, from where it circulated to all the parts of the body through cyclosis. In metazoans, it is diffus into the body cells either directly or through the transport medium (blood and lymp

Assimilation is the ultimate goal of the nutrition. The digested food utilized within the cells either to provide energy or materials to be corporated in the body.

Egestion is elimination of the undigested food either through a temporary anus or a permanent anal opening. The mouth is used for egestion in case where the anus is absent.

12.9 NUTRITION IN AMOEBA, HYDRA, PLANARIA AND COCKROACH

12.9.1 Nutrition in Amoeba:

Amoeba is a microphagous feeder. It feeds upon small aquatic organisms like bacteria, flagellates, ciliates and minute food particles.

When a hungry Amoeba approaches to some food particle, it produces out its pseudopodia in the form of food cup which engulf the food particle by turning into ***food vacuole***. The food also contain some water. This completes ingestion. The next step is digestion which is facilitated by the lysosomes. A few lysosomes surround the food vacuole and get fused with the membrane; to discharge their enzymatic contents (proteases, amylases and lipases) into it. Hence the digestion is intracellular. At this stage the vacuole becomes a digestive vacuole. It decreases in size as the water is withdrawn and its contents first become acidic (pH 5.6) and then alkaline (pH 7.3). When the digestion is completed, the digestive vacuole membrane is drawn into numerous fine canals. The soluble food particles are passed into the canals and finally into the surrounding cytoplasm by micropinocytosis. The digested food, water and minerals are absorbed (absorption) into the cytoplasm and circulate in it, through cyclosis where the food is assimilated into new protoplasm or is oxidized to liberate energy. The undigested food is egested by exocytosis at the rear end.

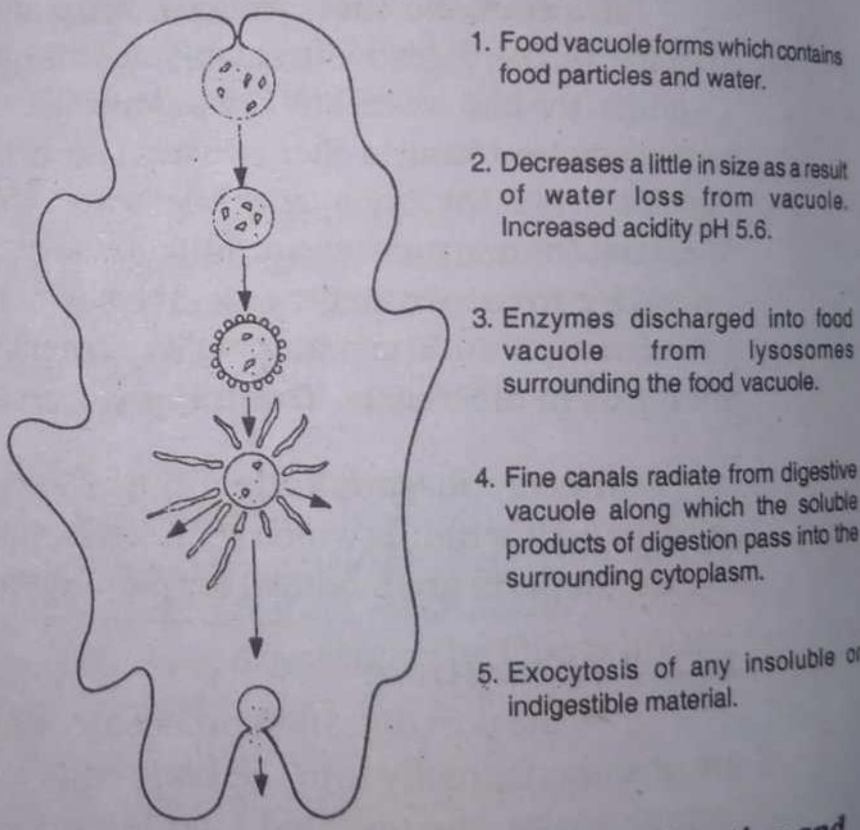


Fig. 12.7 ***Ingestion, digestion and absorption in amoeba***

12.9.2 Nutrition in Hydra:

Hydra is one of the simplest heterotroph to carry out extracellular digestion within the body cavity. It is a macrophagous feeder and feeds upon small aquatic animals like crustaceans, small annelids and insect larvae. When these organisms brush against the projecting cnidocils of nematocysts located on the tentacles, their contents are discharged and the prey is paralyzed. The tentacle then bends over the mouth along with other tentacles. The mouth opens widely, enabling the prey to enter the body resulting in ingestion.

The mouth opens into the body cavity (coelenteron), bounded by the endoderm having glandular and flagellated musculo-epithelial cells. The former secrete proteolytic enzymes which initiate extracellular digestion. The flagellated cells and the contraction of the body wall help in the circulation of food and enzymes and result in mechanical digestion. Hydra can digest proteins, fats and some carbohydrates but not the starch. Extracellular digestion is completed in about four hours. The semi-digested food particles are engulfed by the phagocytic action of the flagellated cells where they are completely digested. Thus the digestion in Hydra is extracellular as well as intracellular. The soluble food particles are diffused through mesogloea into the ectodermal cells and the undigested food is egested through the mouth.

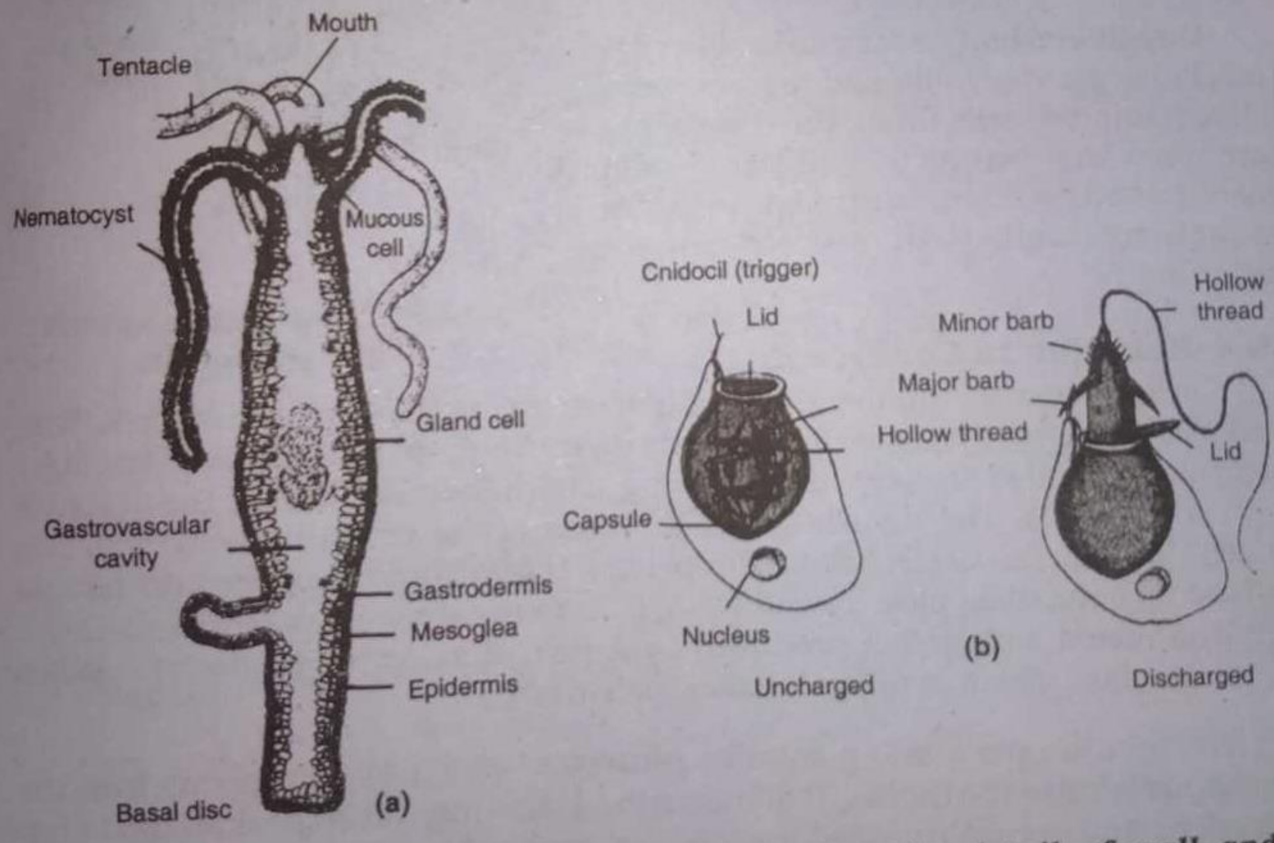


Fig. 12.8 Hydra: (a) Longitudinal section showing the detail of wall and the gastrovascular cavity (b) Nematocysts (discharged and uncharged)

12.9.3 Nutrition in Planaria:

Planaria is a free living flat worm. It is carnivorous and feeds upon small worms, crustaceans, snails and dead animal debris. Planaria perceives the presence of food at a distance and moves towards it. The prey gets entangled in the slimy secretion produced by the mucous glands. Soon the pharynx is everted out through the mouth situated on the mid ventral surface and seizes the prey. It is withdrawn quickly into the pharyngeal sheath along with the prey, where the extracellular digestion starts by pumping action of the pharynx, and the enzymes. The pharynx opens into the intestine which consists of three branches, an anterior and two lateral. All these branches give off numerous branching diverticula which ramify through out the body penetrating into the tissues, ending blindly. Anus is absent and the undigested food is thrown out directly by the mouth. Thus the digestive system is sac type.

The much branched intestine is a means of increasing the surface area for digestion, absorption and distribution of food.

Digestion is both extracellular as well as intracellular. Partially digested food particles are taken into the cells lining the diverticula, where they are completely digested. The digested food is then diffused into the mesenchyme cells which help in the distribution.

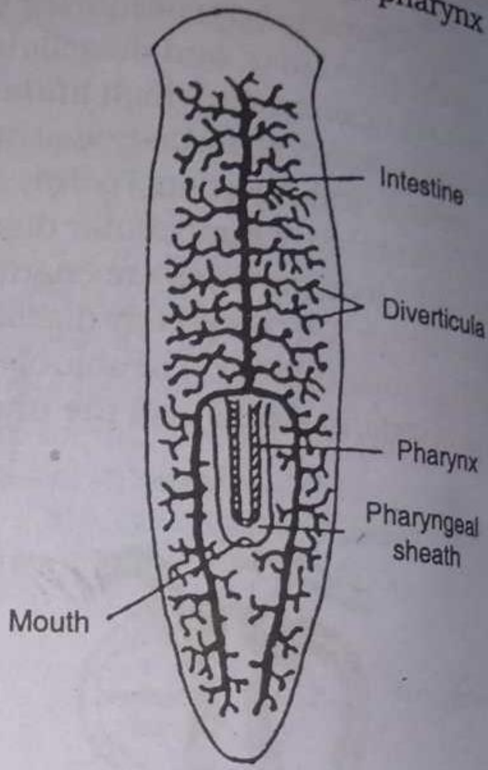


Fig. 12.9 The digestive system of a planarian

12.9.4 Nutrition in Cockroach:

Cockroaches are omnivorous and can eat any kind of organic matter. They search their food by their antennae. Their digestive system is tubular, having a straight slightly coiled digestive tube opening at both the ends. Hence, the digestive system is complete. The mouth lies at the base of the pre-oral cavity which is bounded by the mouth parts, ***labrum*** (upper lip), ***labium*** (lower lip), ***mandibles*** and ***maxillae***. The maxillae pick up and bring food to the mandibles for mastication, where it is mixed with saliva produced by a pair of salivary glands. The saliva contains amylase which acts upon the carbohydrates.

The mouth opens into a tubular ***pharynx*** which in turn opens into the ***oesophagus*** lying in the thorax. It dilates into a large thin walled pear shaped **crop** which opens into a small rounded thick walled ***gizzard*** lined by cuticle in the form of teeth, which grind and strain the food. This portion from pre-oral cavity to gizzard is known as ***fore gut*** or ***Stomodaeum***.

The ***mid gut*** or ***mesenteron*** is a narrow tubular portion having eight hepatic caeca which hang into the haemocoel, ending blindly but opening into the gut. They are lined by glandular cells, which secrete enzymes. The enzymes produced by the mid gut and hepatic caeca flow back into the crop where proteins and fats are digested. The digested food forms a bolus which gets enclosed in a thin chitinous tube secreted by the gizzard, which is a device to protect the lining of mid gut from hard food particles. It is permeable to enzymes and the digested food. The digestion is completed here. The digested food is absorbed in the mid gut.

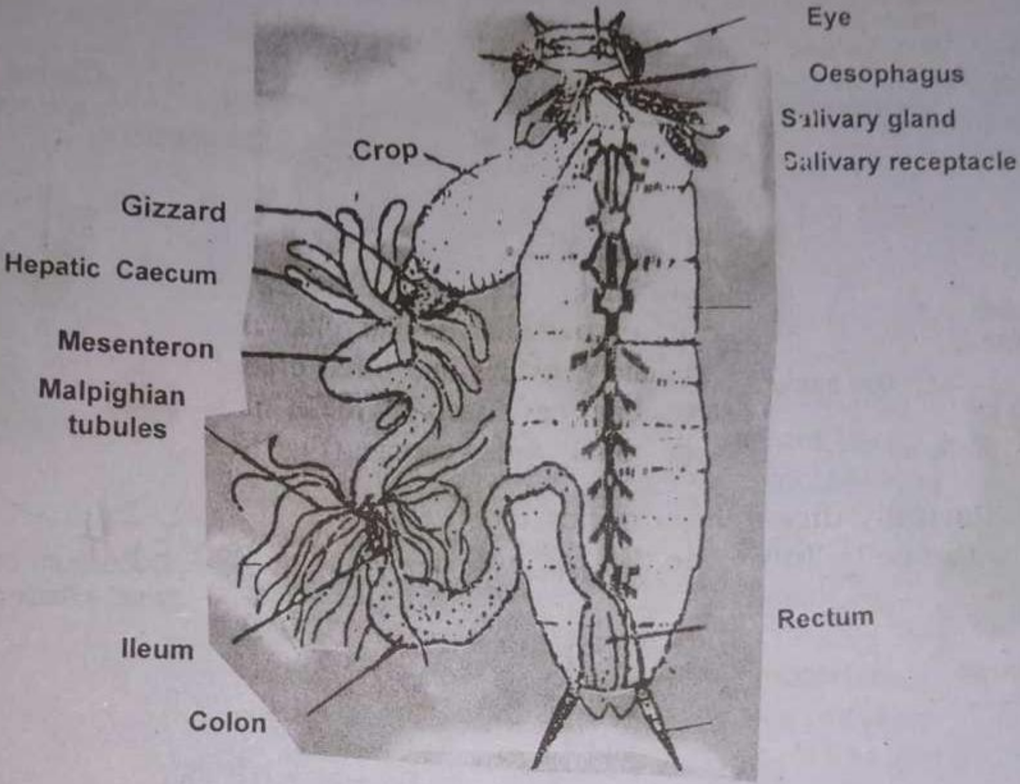


Fig. 12.10 Digestive system of cockroach

The ***hind gut*** or ***proctodaeum*** has a cuticular ectodermal lining. It has a short tubular ***ileum***, a long coiled ***colon*** and a broad ***rectum*** opening out through the ***anus***. The rectum absorbs and conserves the much needed water from the undigested food before expelling out the faeces.

12.10 HUMAN DIGESTIVE SYSTEM

Man is the most advanced heterotroph, having a perfect digestive system with perfect extracellular digestion. The digestive system of man consists of a one way tube into which food is admitted at one end and faecal matter is expelled out from the other end. This tube is commonly known as ***gastro-intestinal tract*** which runs from the mouth to the anus. It is specialized at various places along its length with each region designed to carry out a different role in the over all processes of ingestion, digestion, absorption and egestion.

It begins with the mouth and buccal cavity which is followed by the pharynx, oesophagus, stomach, small intestine comprising the duodenum, jejunum and ileum. The large intestine consists of the caecum bearing appendix, colon and rectum, terminating at the anus.

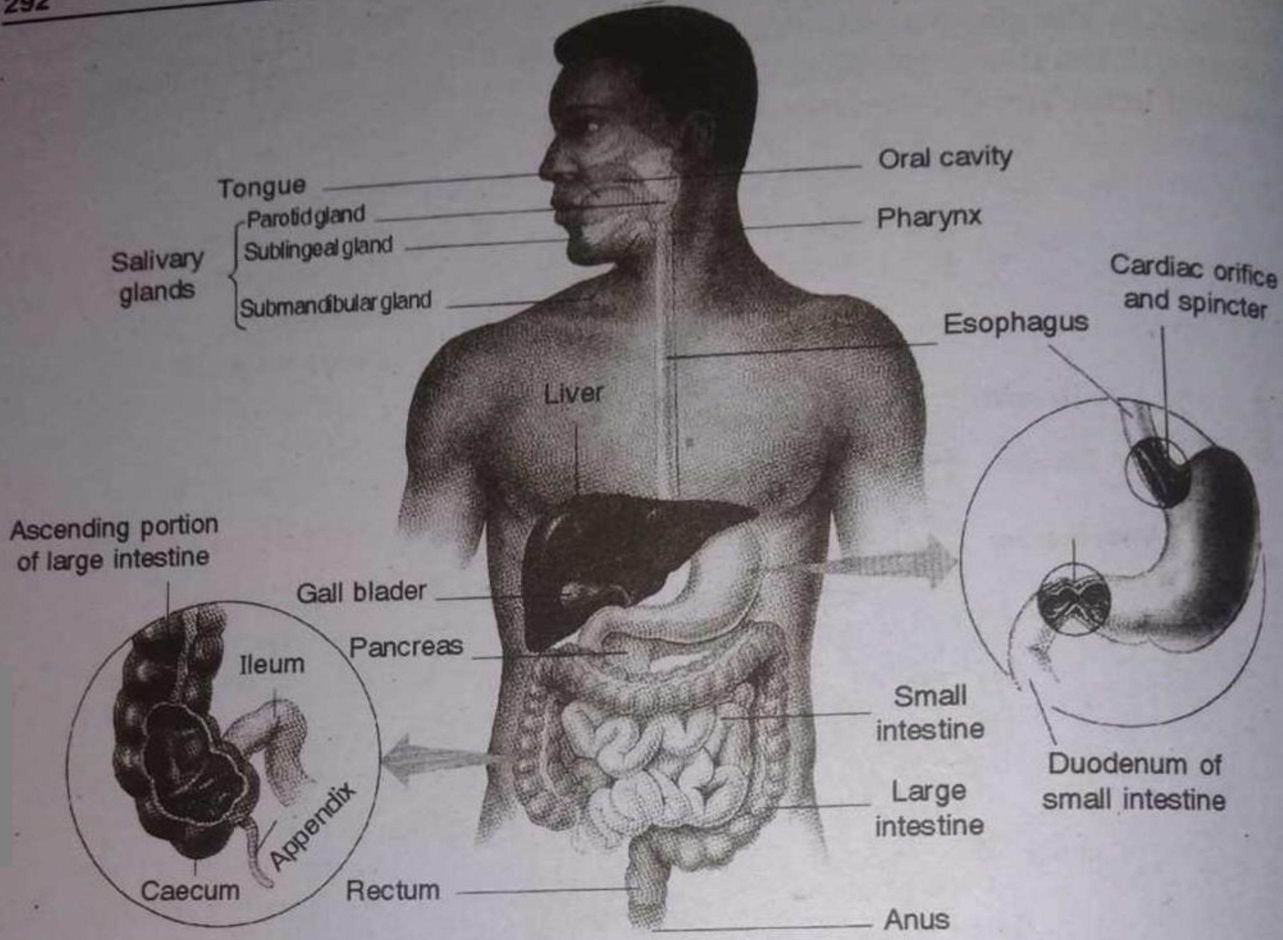


Fig. 12.11 The digestive system in man

Mouth:

It is the anterior opening of the gut, which is bounded by fleshy lips. The lips not only close the mouth but also help in ingestion. The mouth opens into the oral cavity.

12.10.1 Oral Cavity:

It is a wide cavity supported by the bones of the skull. The cheeks forming its side walls, the tongue its floor and the palate its roof. The jaws form the boundary of the mouth. The upper jaw is fixed but the lower jaw is movably attached. Both the jaws bear teeth which are used to masticate food into smaller pieces, resulting in mechanical digestion which increases the surface area of food for action of the enzymes.

Teeth:

Humans have two sets of teeth (diphyodont), deciduous or milk teeth appear first, but are replaced by the permanent teeth. The teeth are of different shapes and sizes (heterodont) and are embedded with in the gums (thecodont). This is correlated with their different functions and different diet. The permanent teeth are 32 in number, consisting of 8 incisors, 4 canines, 8 premolars and 12 molars. The molars have no deciduous predecessors. The incisors are cutting and biting teeth and have flat sharp edges by which the food is cut into smaller pieces for ingestion. The canines are pointed tearing teeth poorly developed in human beings but well developed in carnivores, where they are used for piercing and killing the prey and tearing the flesh. The molars and premolars are the grinders and are specialised for crushing and grinding the food. The human dental formula is

$$\left(i\frac{2}{2}, c\frac{1}{1}, pm\frac{2}{2}, m\frac{3}{3}\right) \times 2 = 32$$

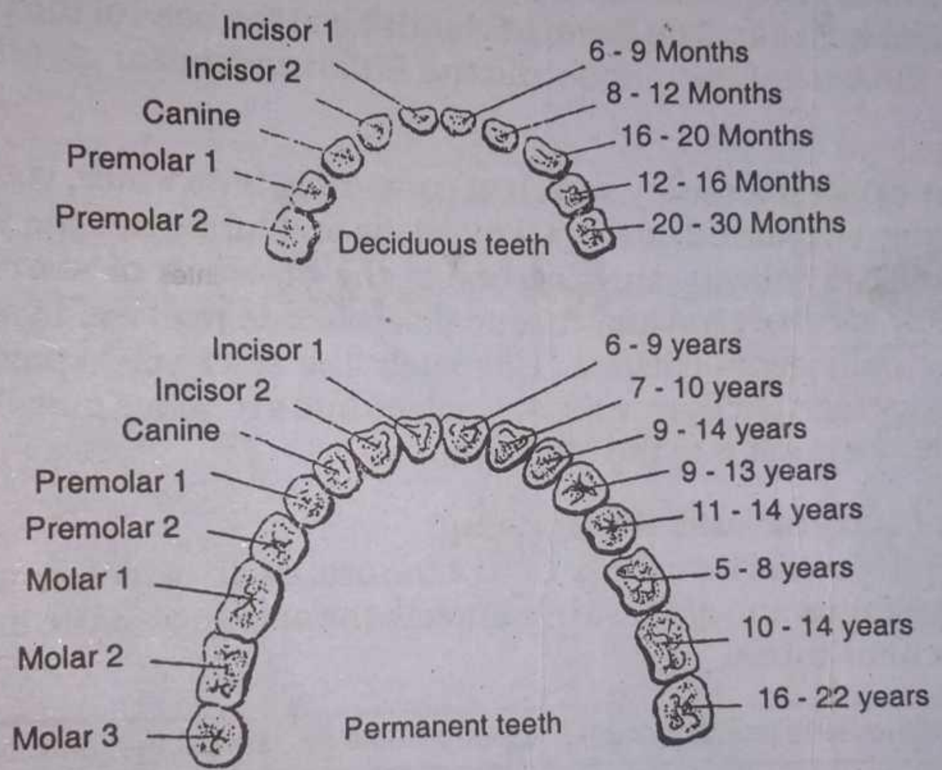


Fig. 12.12 Succession of teeth

Plaque and dental diseases:

The plaque is a mixture of bacteria and salivary materials. If it is allowed to accumulate, the bacteria cause inflammation of the gums. If this condition continues, the inflammation may spread to the root of the tooth and destroy the peridental layer. Eventually the tooth becomes loose and falls off or may have to be extracted. This diseases is known as ***periodontal disease***. Plaque also combines with certain chemicals in the saliva which become harden and calcified forming deposits of ***calculus*** which cannot be removed by brushing. Some of the bacteria in plaque convert sugar into acid which causes ***dental caries***. In which the enamel is dissolved slowly. When the dentine and pulp of the tooth are attacked, produce toothache and loss of tooth. The dental caries is spread by several factors. Prolonged exposure to sugary food stuffs, disturbance of saliva composition, lack of oral hygiene and low levels of fluoride in drinking water. Prevention of dental caries may when they are total parasites and live parasitically permanently within the host. The *facultative* parasites live within the host. After the death of the host continue to feed saprotrophically on the dead body.

The parasites are highly specialized, possessing numerous adaptations, many of which are associated with their hosts and mode of lives.

The parasites may be pathogenic which cause diseases to their hosts or nonpathogenic in case no harm is done to the host.

Examples of some endoparasites of man:

Viruses which cause several diseases like influenza, rabies, yellow fever, poliomyelitis, measles etc.

Bacteria cause tuberculosis, typhoid, cholera, plague, tetanus, leprosy etc.

Fungi are mostly dermatophytes which cause ring worm disease, Athlete's foot and other skin diseases.

Protozoans diseases such as malaria caused by Plasmodium, trypanosomiasis by Trypanosoma, leishmaniasis by Leishmania, amoebiasis by Entamoeba histolytica and many others are common human diseases.

Several **helminths** cause human diseases, such as taeniasis caused by Taenia saginata, hook worm disease caused by Ancylostoma. Round worm (Ascaris) is a common inhabitant of intestines of children causing **Ascarisis**. Enterobius vermicularis causes itching around the anus. Filariasis is caused by **Filaria**.

The examples of ectoparasites of man are Mosquitoes, lice, bed-bugs, fleas etc.

KEY POINTS

- Nutrition is the intake of nutrients by living organisms.
- Nutrients are the food or elements required to get energy and matter for growth and metabolism.
- In autorophic nutrition energy is produced by the oxidation of inorganic substance.
- Minerals required by plants are selectively absorbed from the soil by roots.
- Plants require nine elements, the macronutrients in fairly large amount.
- Symptoms of mineral deficiency depend on the function and mobility of elements.
- Carnivorous plants obtain nitrogen and minerals by killing and digesting insects.
- Organisms which feed on organic food are said to have **heterotrophic nutrition** and are called **heterotrophs**.
- The problem facing any heterotroph is how to acquire and take in food and then break it down into soluble products capable of being absorbed.
- Heterotrophs can be classified into **holozoic**, **saprotrophic** and **parasitic**.
- Holozoic nutrition involves **ingestion**, **digestion**, **absorption**, **assimilation** and **egestion**.
- Digestion may be **intracellular** or **extracellular** involving **mechanical digestion** and **chemical digestion**.
- Extracellular digestion may be through **sac-like digestive system** or **tube like digestive system**.
- The digestive enzymes work by splitting specific chemical bonds in the molecules of the food substances.
- The absorption of digested food takes place by diffusion either directly into the cytoplasm or through villi into the blood for transportation.
- Diarrhoea, Dysentary, Constipation, Piles, Dyspepsia, Peptic ulcer and Food poisoning are **disorders** of the gastro-intestinal tract.
- Animals which live as a parasite on other animals have parasitic nutrition and cause serious diseases in their hosts.

EXERCISE

1. Encircle the correct choice:

(i) Most of the mass of organic material of a plant comes from:
(a) Water (b) Carbon dioxide
(c) Soil minerals (d) Atmospheric oxygen

(ii) Carnivorous adaptations of plants mainly compensate for soil that has a relatively low content of:
(a) Potassium (b) Nitrogen
(c) Calcium (d) Phosphate

(iii) Which of the following nutrients is incorrectly paired with its function in a cell-wall:
(a) Calcium — Formation of cell-wall.
(b) Magnesium — Constituent of chlorophyll.
(c) Iron — Component of chlorophyll.
(d) Phosphorous — Component of nucleic acid.

(iv) An autotrophic nutrition in which energy is produced by the oxidation of inorganic substances is:
(a) Photosynthesis (b) Chemosynthesis
(c) Chemosmosis (d) Chemotrophic

(v) Colour of leaf turns into dull or bluish green due to deficiency of:
(a) Nitrogen (b) Phosphates
(c) Potassium (d) Magnessium

(vi) In which of the organism, digestion is intracellular:
(a) Earth worm (b) Planaria
(c) Grass-hopper (d) Amoeba.

(vii) Digestion is brought about by:
(a) Acid (b) Alkaline solution
(c) Enzymes (d) Minerals

(viii) Bile contains:
(a) Pepsin (b) Trypsin
(c) Amylopsin (d) None of them

(ix) Most of the absorption of food takes place in:

(a) Stomach (b) Small intestine

(c) Large intestine (d) Caecum

(x) Largest gland of the body is:

(a) Liver (b) Pancreas

(c) Pituitary gland (d) Thyroid gland

2. Write detailed answers of the following questions:

(i) What is heterotrophic nutrition? How does it differ from autotrophic nutrition? Give various types of heterotrophs according to their mode of nutrition with examples.

(ii) Describe the human digestive system by the help of a labelled diagram.

(iii) Write down the disorders of human GIT.

(iv) Describe the nutrition in cockroach and planaria.

(v) What is digestion? What are its types? Describe the process of digestion in man.

3. Write short answers of the following questions:

(i) Why N_2 is included in mineral nutrient, although it is not mineral?

(ii) Write some symptoms of N_2 deficiency.

(iii) Why carnivores plants use insects as food?

(iv) What is meant by intracellular and extracellular digestion?

(v) Why hydra has both types of digestion?

(vi) Give the dental formula of human being.