Digestion and Absorption Class 11 Notes Biology Chapter 16

Topic 1 Digestion: The System and Associated Glands

Animals depend on ready-made food for their nutritional requirements. Nutrition is a process by which animal obtain essential and non-essential substances called nutrients.
The way by which organisms derive their nutrients is called mode of nutrition.
It is mainly of two types
(a) Autotrophic or Holophytic The organisms having the capability to form their own food with the help of solar energy, e.g., Plants, Euglena, etc. It is of further two types, i.e., photoautotropic and chemoautotrophic.
(b) Heterotrophic The organisms which cannot use free energy of our atmosphere to synthesise necessary organic compounds as food. These normally obtain the nourishment from the autotrophs.
Based upon the mode of feeding the heterotrophs can be
(i) Holozoic (ii) Saprozoic (iii) Saprophytic
(iv) Osmotrophic (v) Parasitic (vi) Predatorship
The myxotrophic nutrition is the case in which more than one type of . nutritional modes are found within the single animal. The animals like Euglena show this kind of nutrition.
A balanced diet has various components (carbohydrates, hits, proteins, vitamins, water, mineral and roughagfi) in optimum proportion and quantity.
Human Digestive System (Structure)
Biomacromolecules in food cannot be utilised by our body in original form. So, they are subject to a process called digestion (complex food substances are converted to simple absorbable forms).
The system that helps in the complete process of digestion by mechanical and biochemical methods is called digestive system.

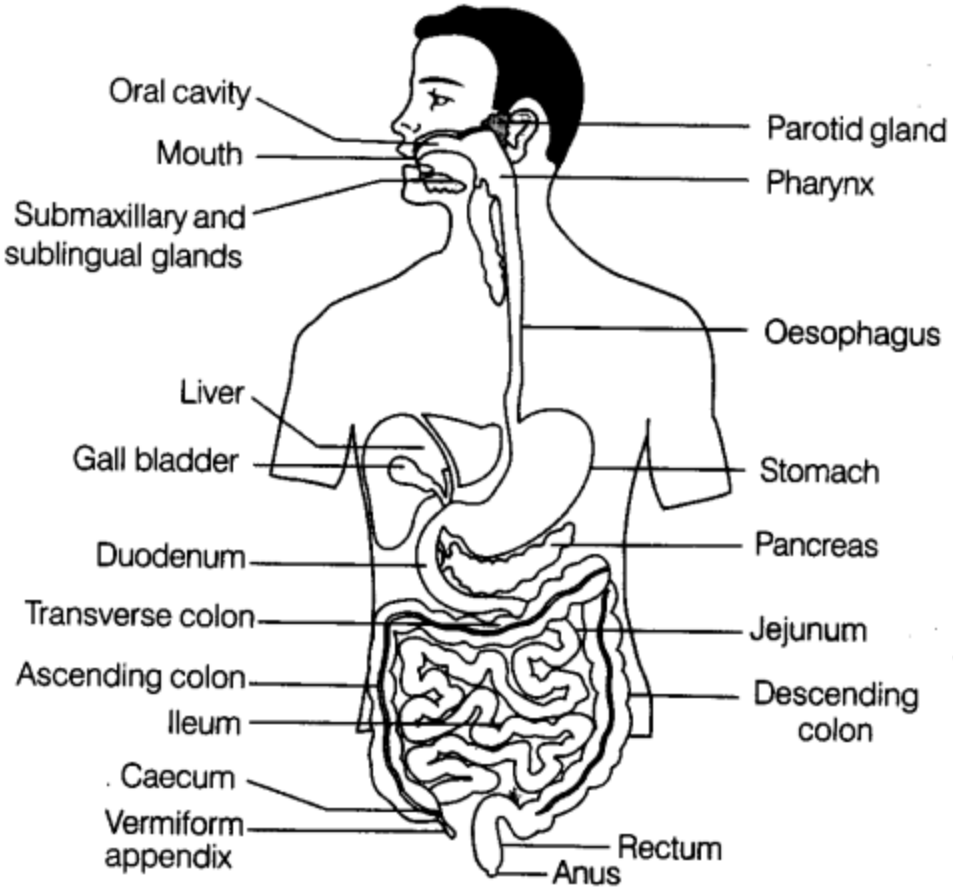


Fig. 16.1 The human digestive system

It is a long tube (about 8-10 m in length) with muscular walls and varying diameter. It begins with an anterior opening, i.e., mouth and opens out posteriorly through anus. It is called canal (not tube), because it opens at both ends [i.e., mouth and anus).

Structure Wall of Alimentary Canal

If a transverse section of an alimentary canal is viewed, the wall of alimentary canal from oesophagus to rectum (large intestine) in general shows following four concentric layers

(a) Serosa It is the outermost layer made up of a thin mesothelium (epithelium of visceral organs) with some connective tissues.

(b) Muscularis It is the second coat present just below the serosa. It is a very thick and contains muscle fibre. It is formed by smooth muscles. It consists of outer longitudinal and inner circular muscle fibres (both are unstriped, i.e., smooth).

In some regions like stomach an additional layer of oblique muscle is found inner to the circular muscle fibres.

(c) Submucosa It lies below the muscular coat. Consist of loose connective tissues richly supplied with nerves, blood and lymph vessels and also with glands in some areas like duodenum. id) Mucosa It is the innermost layer lining the human gut or alimentary canal. It is named so, because it has its major role in secreting mucus in order to lubricate inner lining of gut.

This layer forms irregular folds (rugae) in the stomach and small finger-like folding called villi in the small intestine. It also forms gastric glands in the stomach.

All the four layer shows modification in different parts of the alimentary canal.

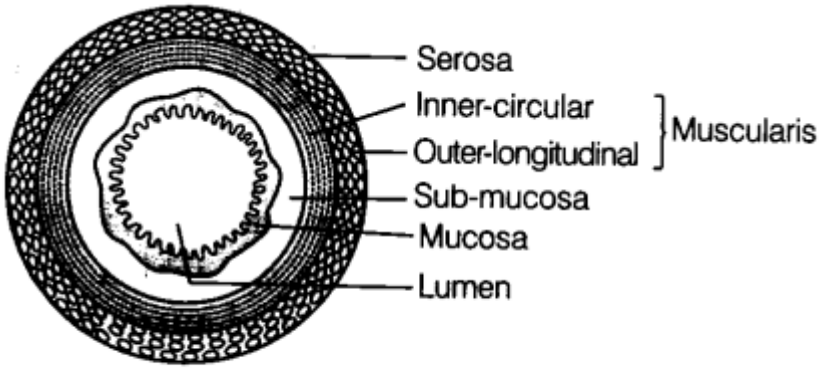


Fig. 16.2 Diagrammatic representation of TS of a gut

Various parts of alimentary canal are discussed below

i. Mouth and Buccal Cavity

Mouth is a slit like opening, bounded by two soft, movable lips. It opens into a small vestibule (space enclosed between lips and cheeks externally and gums and teeth internally), which inturn leads into the buccal or oral cavity.

Oral cavity further comprises of two main components a. Teeth

These are hard structures present in the mouth on both the jaws (i.e., upper and lower jaw). Each tooth is embedded in a socket of jaw bone.

Mammalian teeth are characterised by following three features

* Thecodont The teeth are fixed in sockets. They have very well-developed roots, which are implanted deeply in the jaw bone socket.

* Diphyodont Like other mammals, human beings also has two sets of teeth formed during lifetime. The first set of teeth is temporary and is known as milk or deciduous teeth.

Milk teeth are 20 in number.

* The milk set is replaced by the second set known as permanent teeth or adult teeth. Permanent teeth last for whole life, if lost, cannot be replaced.

* Heterodont An adult human has 32 permanent teeth, but they are of different size, shape and type.

They are of following four types

* Incisors (I) for cutting of food

• Canine (C) for tearing the food

* Premolars (Pm)

* Molars (M) for crushing, grinding and chewing the food.

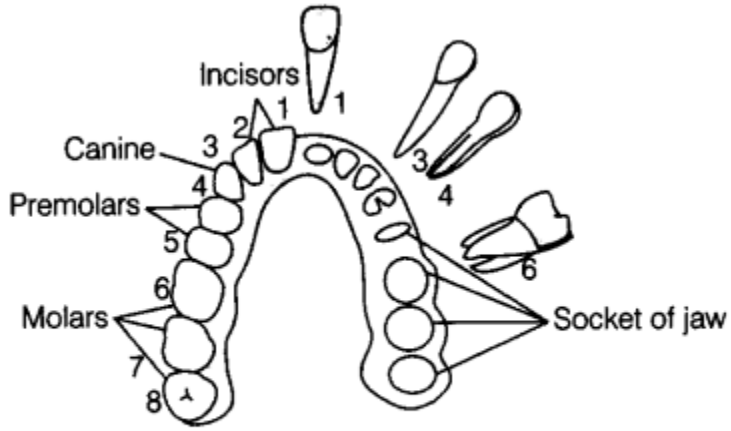


Fig. 16.3 Arrangement of different types of teeth in the jaws on one side and the sockets on the other side

i. Dental Formula

The number of each type of teeth can be expressed by a dental formula, which is the arrangement of teeth in each half of the upper and the lower jaw in the order I, C, Pm, M.

$$\text{Dental formula of humans} = \frac{2, 1, 2, 3}{2, 1, 2, 3} \times 2 = 32$$

or $$\frac{I, C, Pm, M}{I, C, Pm, M} \times 2 = 32$$

b. Tongue

It is a muscular organ, which is freely movable in the oral cavity. A fold called frenulum attaches the tongue to the floor of oral cavity. The upper surface of the tongue bears small projections (elevations) known as papillae. Some of the papillae bear taste buds.

Note:

* Papillae provides a characteristic roughness to the tongue.
* The hard visible chewing surface of tooth helps in the mastication of food and is covered by a thick, shiny and translucent substance called enamel (the hardest substance in the body).
* Taste buds present at the surface of the tongue contain chemosensory cells. Human taste buds are sensitive to four basic
* tastes, i.e., sweet, bitter, salty and sour. These four taste buds are present at different locations of the tongue.

ii. Pharynx

It is a small funnel-shaped chamber located behind the oral cavity. It serves as a common passage for both food and air, i.e., it communicates with both oesophagus (food pipe) and trachea (wind pipe).

The opening of trachea or wind pipe is called glottis, which is guarded by a cartilaginous flap or lid called epiglottis. The glottis normally remain open, but during swallowing of food it gets covered by epiglottis to prevent the entry of food in trachea.

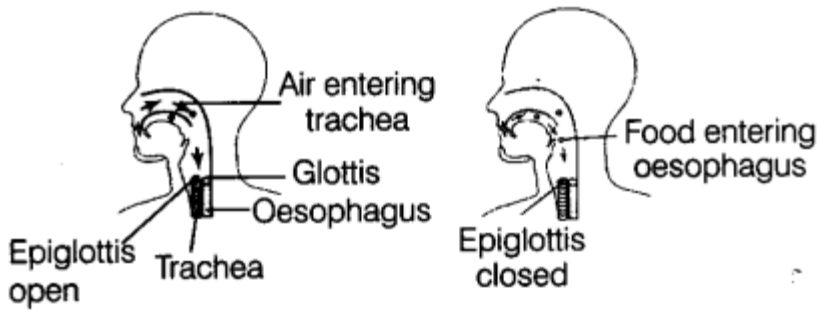


Fig. 16.4 Pharynx under normal condition and during swallowing

iii. Oesophagus

It is the thin, long muscular tube that extend posteriorly passing through the neck, thorax and diaphragm and finally leads into a J-shaped bag- like structure called stomach. A muscular gastro-oesophageal sphincter regulates the opening of oesophagus into the stomach.

iv. Stomach

It is the most dilated- structure of alimentary canal situated between the oesophagus and small intestine. It lies below the diaphragm in the abdominal cavity towards the upper left side.

Pails of Stomach

Stomach has three major parts as given below

(a) Cardiac stomach, the upper portion into which the oesophagus opens.

(b) Fundic stomach, the middle portion.

(c) Pyrolic stomach, the lower portion, which opens into the first part of small intestine, i.e., duodenum.

The terminal pyrolus part of stomach (i.e., opening of stomach into duodenum) is guarded by a pyrolic sphincter.

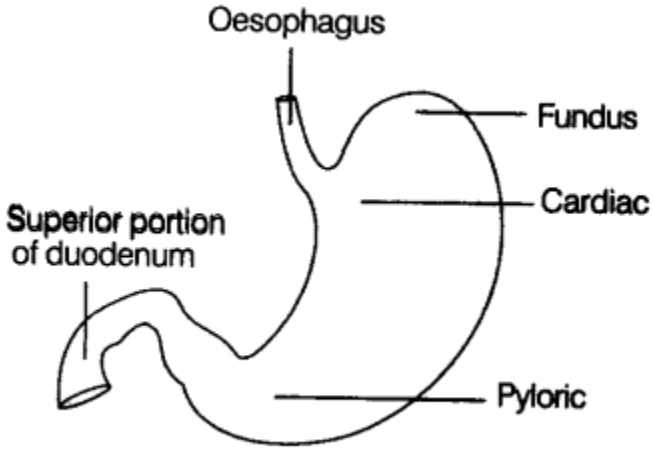


Fig. 16.5 Anatomical regions of human stomach

Functions of Stomach

Stomach serves the following Junctions

(a) Acts as a short term storage reservoir.

(h) The substantial chemical and enzymatic digestion is initiated here (especially of proteins).

(c) Gastric smooth muscles mix and grind the foodstuff by vigorous contractions with gastric secretions.

(d) Food become liquefied in the stomach and is released slowly in the small intestine.

Note:

* The lymphatic tissues of the pharynx and oral cavity are arranged in a ring like manner, that are collectively called Waldeyer's ring. This ring consists of lingual tonsils and palatine tonsils.

The lower – part of oesophagus has only involuntary muscles.

v. Small Intestine

It is the longest part of the alimentary canal, which is about 6 m long in human beings.

It is divisible into three main reports

(a) Duodenum It is U-shaped, widest and shortest part of small intestine.

(b) Jejunum It is the middle part of small intestine, which is about 2.5 m long and coiled.

(c) Ileum It is highly coiled and the longest portion of the small intestine, which and enormously increases the surface area of the intestine.

Absorptive Surface Area of Small Intestine

The structure of small intestine is similar to all other regions of the alimentary canal, but it incorporates three important features, which account for its huge absorptive surface area.

These are as follows

(a) Mucosal folds Inner surface of small intestine is thrown into circular folds, i.e., it is not flat.

(b) Villi The inner mucosa layer of small intestine has, villi (about 1 mm in height), covered with columnar epithelial cells.

(c) Microvilli Numerous microscopic projections of microvilli are produced by the cells lining the villi. These microvilli gives it a brush border appearance showing villi Functions of Small Intestine.

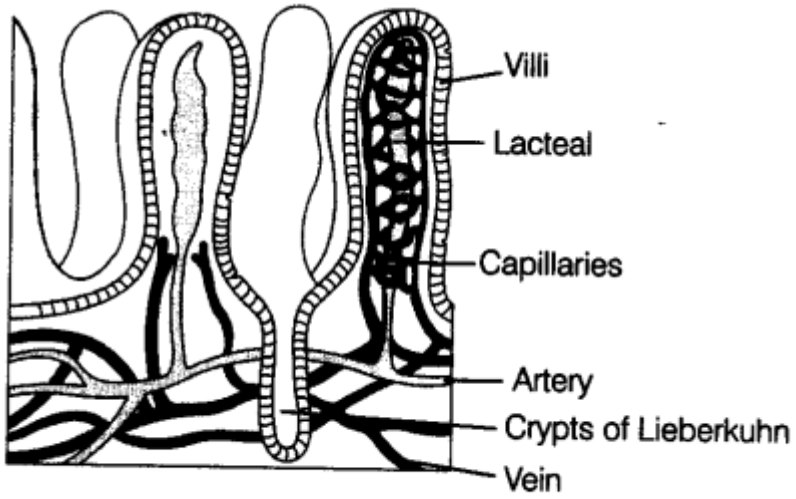


Fig. 16.6 A section of small intestinal mucosa showing villi

Following purposes are served by small intestine

(a) It acts as a major site for the digestion of food as it secretes most of the digestive enzymes and gastro-intestinal hormones.

(b) Maximum absorption of the end products of digestion takes place here, because it contains many villi that increases the surface area of absorption.

(c) It also helps in absorption of fats.

Although it is shorter but, is called large intestine, because it is wider in diameter

than small intestine.

Large intestine lacks villi and microvilli

It is distinguishable into three main parts

(a) Caecum It is a small pouch-like structure connected to the terminal part of small intestine. It is a blind sac that functions as a host for various symbiotic microorganisms. Vermiform appendix, a narrow finger-like projection which is a vestigial organ arises from caecum.

Both the structures are not well-developed in human beings, but in herbivores it is developed very well in order to digest cellulose whose digestion is difficult.

finally opens into large intestine on the right side of the abdominal cavity.

(b) Colon It is the longest part of the large intestine. The caecum opens into colon, which is further divisible into three main parts, i.e., an ascending colon, transverse colon and descending colon.

(c) Rectum It is the last part of the large intestine. The descending colon finally opens into rectum, which serves to store the faecal matter temporarily. It further leads to a short anal canal, which opens to outside through anus.

The anal canal is guarded by another sphincter, i.e., internal and external sphincter,. At the ileocaecal junction is an ileocaecal value is present, that regulates the passage of materials from small to the large intestines.

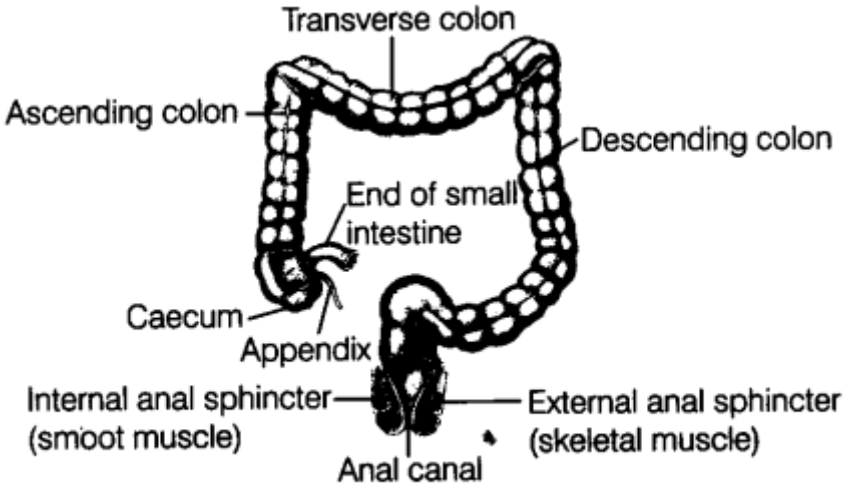


Fig. 16.7 Large intestine and its various parts

Digestive Glands

To bring about the chemical simplification of food, digestive juices are secreted by the different glands. The digestive glands associated with the alimentary canal include majorly salivary glands, the liver and pancreas.

i. Salivary Glands

These are exocrine glands that secretes saliva. There are three pairs of salivary glands in man. All three glands are situated just outside the buccal cavity and secrete salivary juice into the buccal cavity. These are as follows:

(a) Parotid Glands These are largest of the three glands present one on either side of the cheek on the upper palate.

(b) Sub-maxillary or Sub-mandibular Glands These are present at the angle of the lower jaw.

(c) Sub-lingual Gland These are situated beneath the tongue.

Each sublingual gland has about ten small duets called sub-lingual ducts or ducts of Rivinus, which open into the floor of mouth.

ii. Liver

It is the largest gland of the body, an exocrine gland. In adults, it weighs about 1.2-1.5 kg and lies in the abdominal cavity just below the diaphragm and has two lobes, i.e., left and right lobes.
It is a large organ and occupies most of the right side of abdominal cavity.
Liver is a double membrane structure. Interiorly, it is divided into many small units called hepatic or liver lobules (structural and functional units of liver) consisting of many hepatic cells (hepatocytes) that are arranged in the form of cords.
Each lobule is also covered by a thin connective tissue sheath called the Glisson's capsule. Hepatic cells secretes the bile juice, which passes through the hepatic duct into the gall bladder.

Functions of Liver

Liver serves the following functions

(a) It helps in producing RBCs in embryo.
(b) Bile secreted by the liver helps in emulsification of fats, i.e., breaking down of fats into very small micelles.
(c) Bile also activates lipases.
(d) It also produces heparin for preventing clotting of blood inside the blood vessels.

Gall Bladder

It is a small pear-shaped, thin muscular sac-like organ situated just below the liver. It is attached by connective tissues to liver. The duct of gall bladder, i.e., cystic'duct along with the hepatic duct form a common bile duct, which regulates the amount of bile to be discharged into the duodenum.
After certain distance, the bile duct and pancreatic duct (duct of pancreas) form common hepato-pancreatic duct, which open into duodenum. It is guarded by a sphincter called the sphincter of oddi.
The common hepato-pancreatic duct carries both the bile (from liver) as well as pancreatic juice (from pancreas) into the duodenum.

iii. Pancreas

It is a compound elongated organ situated partly behind the stomach between the limbs of the U-shaped duodenum. As it is a mixed gland, it has both exocrine as well as endocrine activity.
An alkaline pancreatic juice containing enzymes is secreted by its exocrine portion and the endocrine portion is responsible for the secretion of hormones, insulin and glucagon.

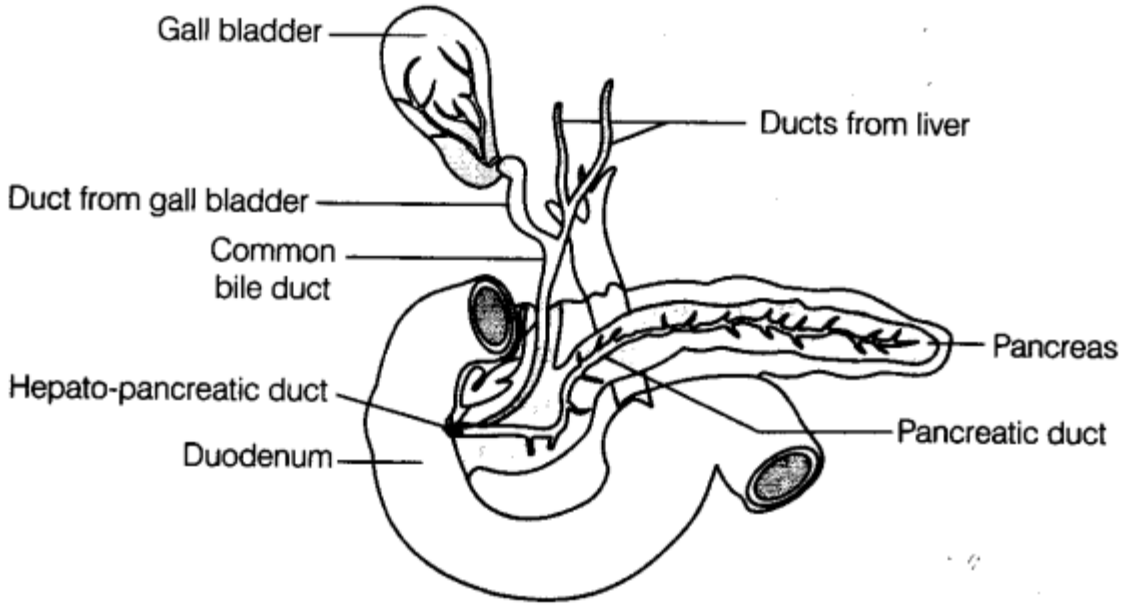


Fig. 16.8 Duct systems of liver, gall bladder and pancreas

Other Glands

Apart from the above mentioned major glands, other glands also plays an important role in completion of the process of digestion.

These are mentioned below as

Gastric Glands

The glands of stomach are called gastric glands. These are present in the mucosa of the stomach.

The gastric gland contains the following three types of secretory cells

(a) Mucus or goblet cells, secretes alkaline mucus.

(b) Peptic o(chief or zymogenic cells, secretes inactive precursors of gastric enzymes.

(c) Parietal or oxyntic cells, secretes HCl and CIF (Castles Intrinsic Factor).

Intestinal Glands

The epithelium of intestine bears a large number of glands. Most of these glands are formed by the modification of the surface epithelial cells and are located on villi.

(a) Brunners glands are present only in the submiicosa of duodenum (not in ileum and jejunum).

(b) The lamina propria of small intestine contains large masses of lymphocyte cells called lymph nodules or Peyers patches. These help in destroying harmful bacteria of the region.

(c) The mucus portion contain simple, tubular intestinal glands or crypts of Leiberkuhn.

These are pit-like glands with three types of cell, i.e.,

* Undifferentiated epithelial cells
* Zymogenic cells or cells of Paneth
* Argentaffin or enterochromaffin cells.

In general intestinal juice is called succus entericus (secretion of cells of crypts of Lieberkuhn mainly,

i. e„ goblet cells and brush-bordered epithelial cells).

Note:

* The estimated number of gastric glands in humans is about 35 millions (3.5 crore).

* The unicellular goblet cells are also present in small intestine. Infact, these glands are present throughout the alimentary canal and secrete mucus.

Topic 2 Digestion : The Process and Control

The process of digestion involves the conversion of large, complex and non-diffusible substances into their respective simpler forms. The complete process of digestion is accomplished by mechanical and chemical processes.

Mobility of Gut

Alimentary canal being so long, does not allow the food to get jammed along its length. This is due to the mobility of gut, which helps the food to move forward. The alimentary canal or gut shows following movements

i. In Buccal Cavity

The buccal cavity shows two major functions

(a) Mastication of Food It is the very first movement of the alimentary canal seen in buccal cavity. It involves the movement of teeth, which helps in chewing the food and the tongue, which help the food to mix thoroughly in the saliva, with the help of mucus.

The mucus lubricates and adhere the masticated particles of food into a bolus (mass of food that has been chewed before swallowing) and push it backward towards the pharynx for deglutition.

The mastication of food is a voluntary process (in human being).

(b) Swallowing (Deglutition) It is the process of passing bolus or mass of food in the oesophagus from the buccal cavity through pharynx.

The food is pushed back against the epiglottis, at the same time epiglottis covers the glottis (as already discussed in 1st topic). Due to this the oesophagus opening becomes wider and food enters it.

The bolus further passes down through the oesophagus by a successive wave (peristalsis) as a reflex along with the constriction of the oesophageal opening, which takes the food down towards the stomach.

ii. Peristalsis

It is the reflex wave that comprises of a series of muscle contraction that occurs in the complete digestive tract.

It pushes the food in the forward direction (away from the mouth).

Mechanism of Digestion

In human being, the digestion of food starts in the buccal cavity and continues till the anus of large intestine.

The mechanism of digestion continues in the following steps

i. Digestion in Buccal or Oral Cavity

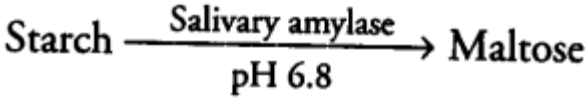
Digestion starts in the oral cavity by the chemical hydrolytic action of the carbohydrate splitting enzyme, salivary amylase.

The saliva secreted into oral cavity contains electrolytes (Na^+,K^+, Cl^-, HCO_3, etc.) and enzymes, i.e., salivary

amylase and lysozyme (acts as an antibacterial agent that prevents infections).

About 30% of the starch gets hydrolysed in the oral cavity by the action of salivary amylase (at optimum pH 6.8) into a disaccharide,

i. e., maltose.



ii. Digestion in Stomach

The stomach stores the food for around 4-5 hours. Internal mucosa of stomach contains gastric glands, which mainly comprises of three types ofcells

(a) Mucus or neck cells for secreting mucus.

(b) Peptic or chief or zymogenic cells for secreting proenzyme pepsinogen.

(c) Parietal or oxyntic cells for secreting HCl and intrinsic factor (essential for vitamin-B_{12} absorption).

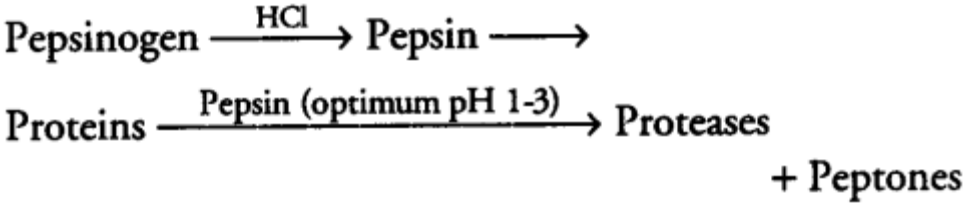
The gastro-oesophageal sphincter controls the passage of food into the stomach. Food is slowly released from the stomach in small quantities into the small intestine, so that a slow process of digestion and absorption can occur.

The food mixes thoroughly with the acidic gastric juice secreted in the stomach by the churning movements of its muscles and becomes semi-digested, acidic, pulpy mass called chyme. The HCl and the enzymes of the gastric juice now helps in the chemical simplification of food.

The enzymes of stomach and their actions are given below

a. Pepsin

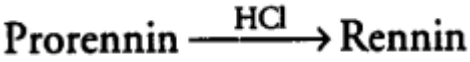
On exposure to HCl, the proenzyme pepsinogen gets converted into pepsin (proteolytic enzyme of the stomach) that further converts proteins into proteases and peptones (peptides).



Pepsin usually attacks the peptide bonds between amino acids. It can attack all proteins except keratins, protamines, histones, etc.

b. Rennin

It is a proteolytic enzyme found in gastric juice of only infants, in its inactive form. Its secretion takes place in order to digest the milk proteins.



c. Gastric Lipases

Small amounts of lipases are also secreted by the gastric glands. Activity of this enzyme is inhibited in the stomach by the acidic condition.It act on emulsified fats and also help in digesting around 25% of milk fat (in infants).

It is mainly the digestion of proteins that occurs in the stomach.

Apart from all these enzymes, the amount of mucus and bicarbonates present in the gastric juice plays an important role in the lubrication and protection of mucosal epithelium from excoriation by the highly acidic pH.

iii. Digestion in Small Intestine

To further facilitiate the digestion of food, muscularis layer of small intestine shows various types of movements which allows a thorough mixing up of food with various secretions in the intestine.

These contractions of muscles in the small intestine allows the further churning and kneading of the chyme and finally pushing it into the large intestine.

The respective digestive juices from the liver (bile), pancreas (pancreatic juice) and srtiall intestine (intestinal juices) are released into the small intestine to bring out the further chemical simplification of food. The , pancreatic juice from the pancreas and the bile from the liver are released through the hepato-pancreatic duct.

Enzymes from Pancreas

The pancreatic juice secreted from the pancreas contains the various inactive enzymes.

These are as follows

(a) trypsinogen (b) chymotrypsinogen
(c) procarboxypeptidases (d) amylases (e) lipases (f) nucleases

Trypsinogen is activated by an enzyme enterokinase secreted by intestinal mucosa into active trypsin which in turn activates the other enzymes of pancreatic juice.

$$\text{Trypsinogen} \xrightarrow[\text{pH (7-9)}]{\text{Enterokinase}} \text{Trypsin}$$

* The proteins, proteases and peptones (partially hydrolysed form of proteins) present in the chyme (reaching the intestine) are acted upon by the proteolytic enzymes of pancreatic juice. These are given below as

$$\left.\begin{matrix}\text{Proteins}\\ \text{Peptones}\\ \text{Proteoses}\end{matrix}\right\} \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin / Chymotrypsin}} \text{Dipeptides}$$

* Carbohydrates in the chyme are hydrolysed by pancreatic amylase into disaccharides.

$$\text{Polysaccharides (starch)} \xrightarrow{\text{Amylase}} \text{Disaccharides}$$

* Nucleases in the pancreatic juice acts on nucleic acids to form nucleotides and nucleosides.

$$\text{Nucleic acids} \longrightarrow \text{Nucleotides} \longrightarrow \text{Nucleosides}$$

Enzymes from Liver

The bile secreted from the liver is released into duodenum of small intestine. Bile contains the bile pigments, i.e., bilurubin and biliverdin, bile salts, cholesterol and phospholipids.

Thus, fats are broken down into di and monoglycerides by the action of lipases.

$$\text{Fats} \xrightarrow{\text{Lipases}} \text{Diglycerides} \xrightarrow{\text{Lipases}} \text{Monoglycerides}$$

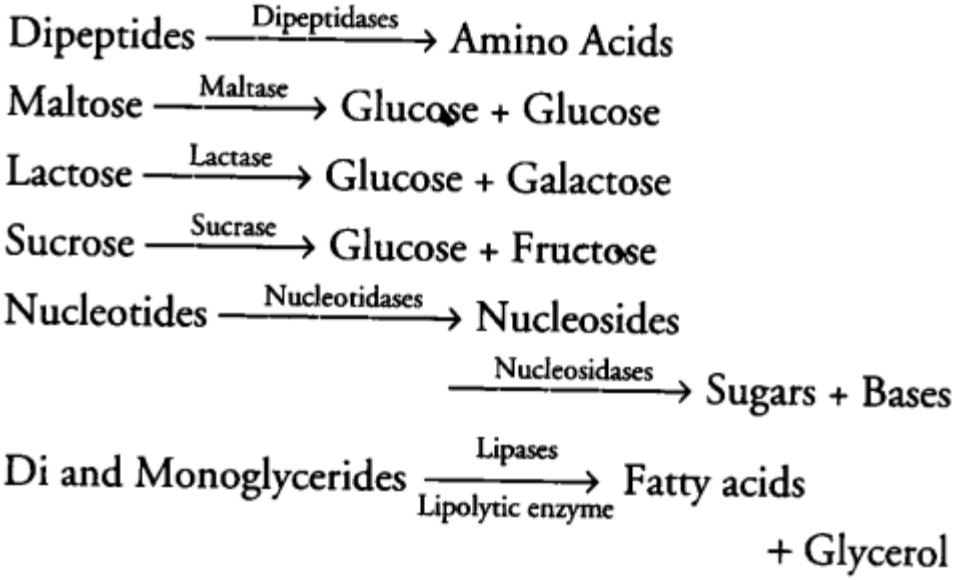
Note:

* Bile does not contain any enzymes as gastric juice. It helps in emulsifying fats, i.e., in breakdown of fats into very small micelles which are kept suspended in an aqueous medium.
* The process of emulsification is basically carried out by the salts of bile. This increases the surface area of fat available for digestion by the lipase (as bile also activates lipases).

Enzymes from Intestine

Intestinal mucosal epithelium has goblet cells (secretes mucus). Thus, the secretions

of the brush border cells of mucosa together with the goblet cell secretions forms the intestinal juice (also known as succus entericus).
The succus entericus thus, contains various enzymes
(a) Disaccharidases, e.g., Maltase for digestion of maltose into glucose.
(b) Dipeptidases
(c) Lipases
(d) Nucleosidases
Pancreatic and intestinal lipases together helps in the emulsification of fats.
The mucus along with the bicarbonates from the pancreas helps in protecting the mucosal layer of intestine from the action of acid and also provides an alkaline medium (pH-7.8) for enzymatic activities.
Glands (Brunner's gland) from sub-mucosal layer of intestine also helps in this.
Hence, all the enzymes in the succus entericus acts on the end products of the above mentioned reactions in order to form their respective simpler forms.



All these final steps takes place very close to mucosal epithelial cells of the intestine.
All the biomacromolecules mentioned above breakdown in the duodenum region of small intestine, while the simpler forms are absorbed in the other two regions of small intestine, i.e., jejunum and ileum.

Digestion in Large Intestine

The last stage of chemical simplification of food occurs in the last part of the alimentary canal, i.e., large intestine. This is carried out by bacterial action. Glands of this region tends to secrete mucus, i.e., enzymes are not secreted into this part of the digestive system.
The undigested and the unabsorbed substances are finally passed on to the large intestine.

Note:

* There are more than 500 species of bacteria found in the colon region of the large intestine which are not usually harmful as long as they remain in the large intestine.
* Infact, all these bacteria synthesise vitamin-K and B_{12}, also helps in absorption of calcium, magnesium and zinc (by increasing the acidity of colon region).

Followingfunctions areperformed by the large intestine

(i) Absorption of some water, minerals and certain drugs.
(ii) Secretion of mucus which helps in adhering the waste (undigested) particles together and lubricating it for an easy passage.

No significant digestive activity occurs in this region of digestive tract. .
The undigested, unabsorbed substances called faeces, enters into the caecum region of the large intestine (through the ileo-caecal valve, which prevents the back flow of faecel matter). It is temporarily stored in the rectum till defecation (egestion) through the anus.
Apart from absorbing vitamins secreted by various types of bacteria, large intestine also helps in absorbing water and electrolytes such as Na^+, Cl^-.

Neural and Hormonal Control of Digestion

For proper coordination- and functioning of different parts of the gastrointestinal tract, it should be under a proper, neural and hormonal control.

Neural Control

Secretion of saliva is stimulated by the sight, smell and the presence of food in the oral cavity. Similarly, the gastric and intestinal secretions are also under the control of neural signals.
The muscular activities of different parts of the alimentary canal are also moderated by neural mechanisms (both local and through CNS).

Hormonal Control

The major hormones that control the functions of digestive system are produced and released by the cells in the mucosa of the stomach and the large intestine.