CHAPTER-16

DIGESTION AND ABSORPTION

DIGESTION

The process of conversion of complex food into a simpler absorbable form is called digestion.

DIGESTIVE SYSTEM

The human digestive system consists of the alimentary canal and associated glands.

ALIMENTARY CANAL

The alimentary canal is a long coiled tube having a muscular wall & glandular epithelium extending from mouth to anus.

The organs comprising the alimentary canal include the **mouth** and **pharynx** (called a buccopharyngeal cavity), **oesophagus**, **stomach,** and **intestine**.

MOUTH

The mouth consists of a **vestibule** and **a buccal or oral cavity**.

A vestibule is a space that is bounded externally by lips, cheeks and internally by the gums and teeth.

The buccal or oral cavity is bounded by palate above (dorsally), throat with tongue below, and jaws with teeth on the sides.

The palate forms the roof of the buccal cavity and is differentiated into the anterior **hard palate** and posterior **soft palate**.

The hard palate has a uvula as a free hanging flap which closes the internal nares during swallowing of the food bolus.

The soft palate bears transverse palatine rugae supported by bones for holding food during mastication.

The **tongue** is a freely movable muscular organ attached to the floor of the oral cavity by the frenulum.

Tongue not only helps in ingestion, mastication, and deglutition of food but also help in voice production and tasting of food.

The upper surface of the tongue has small projections called **papillae**, some of which bear taste buds.

Teeth are hard structures meant for tearing cutting, crushing, and holding food.

Each tooth is embedded in a socket of the jaw bone. This type of attachment is called **thecodont**.

The majority of mammals including human being forms two sets of teeth during their life, a set of temporary milk or deciduous teeth replaced by a set of permanent or adult teeth. This type of dentition is called **diphyodont**

An adult human has 32 permanent teeth which are of four different types (heterodont dentition) - incisors (I), canine (C), premolars (PM), and molars (M).

Arrangement of teeth in each half of the upper and lower jaw in the order I, C, PM, M is represented by a dental formula which in humans is.

Dental formula

a. Temporary teeth in man = $\frac{2102}{2102} = \frac{5}{5} \times 2 = 20$

b. Teeth at the age of 20 years = $\frac{2122}{2122} = \frac{7}{7} \times 2 = 28$

c. Human beings (Adult) $\frac{2123}{2123} = \frac{8}{8} \times 2 = 32$

teeth can be distinguished as **homodont** or **heterodont**.

Homodont: When all the teeth are structurally and functionally similar. E.g., Vertebrates except metatherian and eutherian mammals.

Heterodont: When the teeth are different in structure and functions. They are distinguished into four types - **incisors**, **canines**, **premolars,** and **molars**. E.g., Metatherian and eutherian mammals.

Incisors (8): These are the front, long, curved, and possess sharp-edged teeth. They are adapted for cutting or cropping and biting.

Canines (4): It is one-pointed or (dagger-shaped) canine in each maxillary of the upper jaw and each dentary of the lower jaw next to the incisors. They are meant for piercing, tearing, and offense and defense. These are poorly developed in man.

Premolars (8): They are meant for crushing, grinding, and chewing. They are also called cheek teeth.

Molars (12): They are also called cheek teeth. They are specialized for crushing and grinding the food.

Enamel represents the hardest substance of the body. It is completely acellular and avascular and nonregenerable. It helps in the mastication of food.

The element that hardens the tooth enamel is **fluorine**.

PHARYNX

The oral cavity leads into a short **pharynx** which serves as a common passage for food and air.

The esophagus and the trachea (windpipe) open into the pharynx.

A cartilaginous flap (called **epiglottis**) prevents the entry of food into the glottis – the opening of the windpipe – during swallowing.

ESOPHAGUS

The esophagus is a thin, long tube (25 cm) which extends posteriorly passing through the neck, thorax, and diaphragm and leads to a 'J' shaped bag-like structure called stomach.

A muscular sphincter (gastro-oesophageal) regulates the opening of the esophagus into the stomach.

STOMACH

The stomach is the most distensible and widest organ of the alimentary canal.

An empty stomach possesses folds called **gastric rugae**, which disappears when the stomach is distended with food.

The stomach, located in the upper-left portion of the abdominal cavity, has three major parts – a **cardiac portion** into which the esophagus opens, a **fundic region,** and a **pyloric portion**, which opens into the first part of the small intestine.

The cardiac part is so-called because it is present near the heart. It is broad at the upper part with cardiac sphincter which prevents **regurgitation of food**.

The fundus is commonly filled with air and gases.

INTESTINE

The intestine is responsible for most of the digestion and absorption of food and usually the formation of dry feces.

It is divided into two parts – **small intestine** and **large intestine**.

Small intestine

The small intestine is distinguishable into three regions, a 'U' shaped **duodenum**, a long coiled middle portion **jejunum,** and highly coiled **ileum**.

The opening of the stomach into the duodenum is guarded by the pyloric sphincter.

The ileum opens into the large intestine.

Duodenum has the ampulla of Vater which receives both the bile duct (from the liver) and the main pancreatic duct (from the pancreas) and whose opening was guarded by the sphincter of odd.

The ileum is thinner than the jejunum and less vascular. It is the longest part (3.5m) of the small intestine.

The small intestine is the major site of digestion and absorption of nutrients.

Large intestine

It consists of **the caecum**, **colon,** and **rectum**.

The caecum is a small blind sac which hosts some symbiotic microorganisms.

A narrow finger-like tubular projection, the **vermiform appendix** which is a vestigial organ, arises from the caecum. The caecum opens into the colon.

The colon is divided into three parts – an ascending, a transverse, and a descending part. The descending part opens into the rectum which opens out through the anus.

The colon is concerned with the absorption of water of undigested food, salts, vitamins, etc. Hence, concerned with feces formation.

Colon bacteria also synthesized vit. B_{12} and K.

Rectum has a strong sphincter muscle in its wall. The sphincter keeps the canal as well as anus, closed when not used for defecation.

The anal canal connects the rectum with the anus and it is about 3 cm. long.

The anus is the terminal inferior opening of the alimentary canal, which is guarded by an internal involuntary sphincter and an external voluntary sphincter.

The **chief function of the large intestine** is the absorption of water and the elimination of solid waste.

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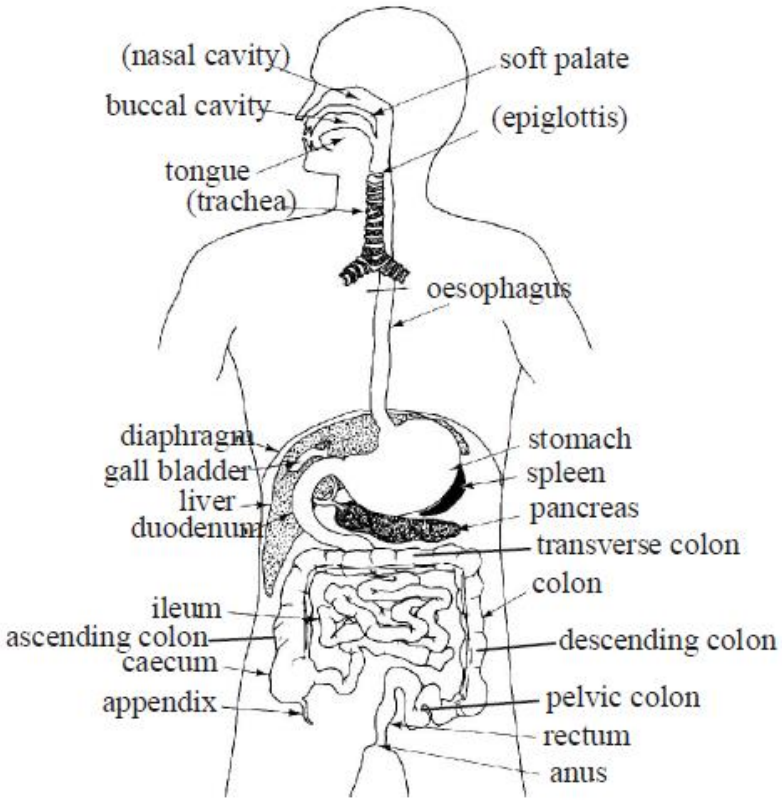


Fig. : Digestive system of human (The labelling in parenthesis are of respiratory system)

DIGESTIVE GLANDS

The digestive glands associated with the alimentary canal include the salivary glands, the liver, and the pancreas.

Saliva is mainly produced by three pairs of salivary glands, the parotids (cheek), the sub-maxillary/sub-mandibular (lower jaw), and the sublingual (below the tongue).

These glands situated just outside the buccal cavity secrete salivary juice into the buccal cavity.

The liver is the largest gland of the body weighing about 1.2 to 1.5 kg in an adult human.

It is situated in the abdominal cavity, just below the diaphragm, and has two lobes.

The hepatic lobules are the structural and functional units of the liver containing hepatic cells arranged in the form of cords.

Each lobule is covered by a thin connective tissue sheath called the Glisson's capsule.

The bile secreted by the hepatic cells passes through the hepatic ducts and is stored and concentrated in a thin muscular sac called the gall bladder.

The duct of gall bladder (cystic duct) along with the hepatic duct from the liver forms the common bile duct.

The bile duct and the pancreatic duct open together into the duodenum as the common hepato-pancreatic duct which is guarded by a sphincter called the sphincter of Oddi.

The pancreas is a compound (both exocrine and endocrine) elongated organ situated between the limbs of the 'U' shaped duodenum.

The exocrine portion secretes an alkaline pancreatic juice containing enzymes and the endocrine portion secretes hormones, insulin, and glucagon.

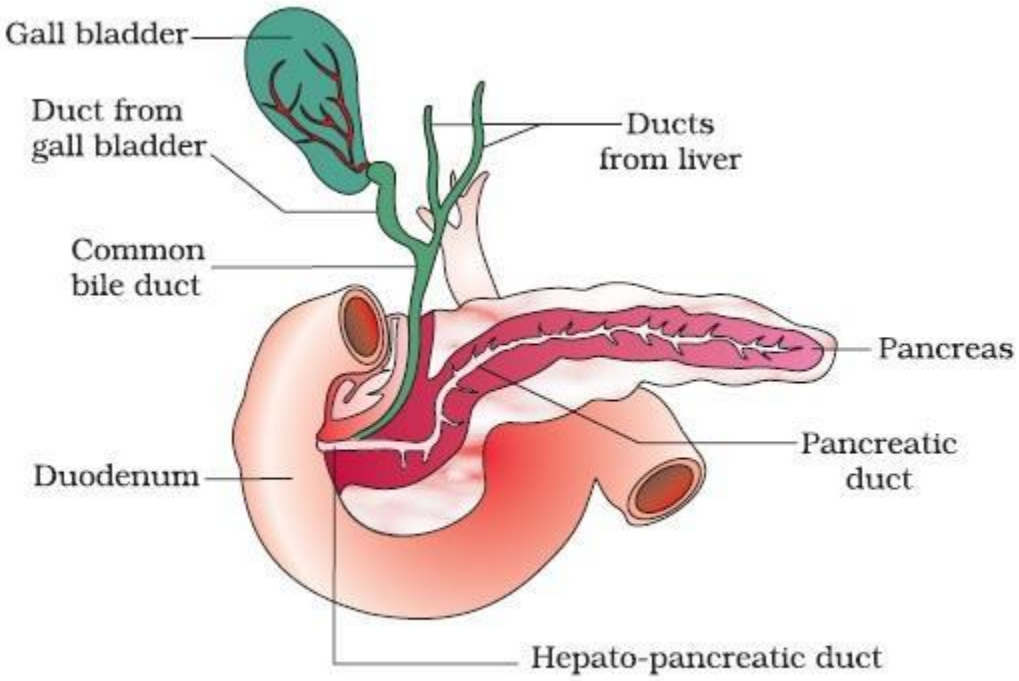


Figure 16.6 The duct systems of liver, gall bladder and pancreas

The mucosa of stomach has gastric glands. Gastric glands have three major types of cells namely –

(i) mucus neck cells which secrete mucus;
(ii) peptic or chief cells which secrete the proenzyme pepsinogen; and
(iii) parietal or oxyntic cells which secrete HCl and intrinsic factor (factor essential for absorption of vitamin B12).

DIGESTION OF CARBOHYDRATES

The **digestion** of **carbohydrates** begins in the mouth.

The salivary enzyme amylase begins the breakdown of food starches into maltose, a disaccharide.

As the bolus of food travels through the esophagus to the stomach, no significant **digestion** of **carbohydrates** takes place.

Maltase breaks down maltose into glucose.

DIGESTION OF PROTEINS

The digestion of proteins takes place in the stomach with the help of protease and pepsin enzymes, which breaks down the proteins into **amino acids**.

The process is facilitated by the hydrochloric acid present in the stomach which activates pepsinogen to form pepsin.

Amino acids are tiny elements which get absorbed into the blood system through the wall of the small intestine.

The enzymes in the succus entericus act on the end products of the above reactions to form the respective simple absorbable forms. The final steps in digestion occur very close to the mucosal epithelial cells of the intestine.

DIGESTION OF LIPIDS

Lipids are organic compounds comprising fatty acids, which are insoluble in water.

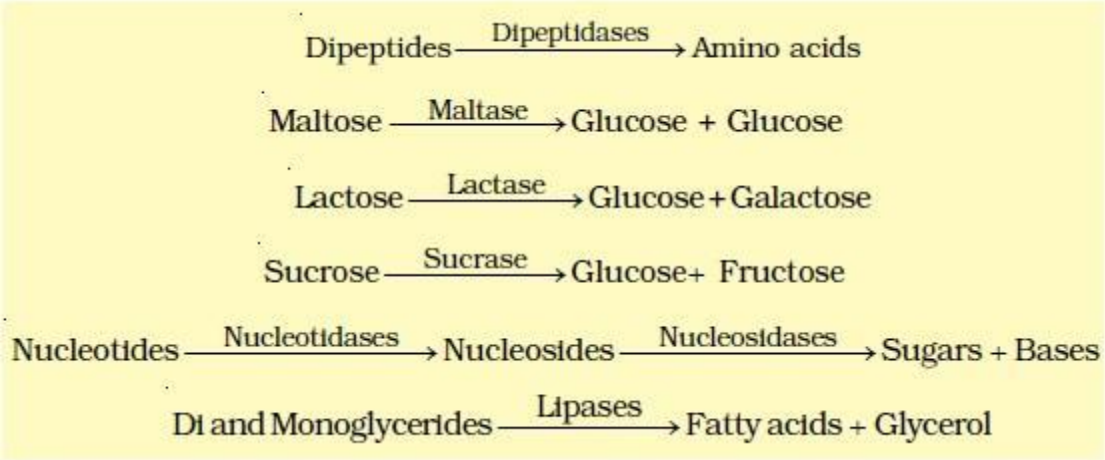
Fats are the most common examples of lipids.

The insoluble property of lipids makes the digestion and absorption of fats a complicated process.

Since they are hydrophobic, fats stick together as a large globule of insoluble mass after reaching the stomach.

It is broken down with the help of bile juice, which contains bile pigments.

Pancreatic lipase breaks down fats into tiny molecules of free fatty acids and monoglycerides, which are small enough for the small intestine to push through into the bloodstream.



ABSORPTION OF DIGESTED FOOD

Absorption is the process by which the end products of digestion pass through the intestinal mucosa into the blood or lymph.

It is carried out by passive, active or facilitated transport mechanisms.

Small amounts of monosacharides like glucose, amino acids and some of electrolytes like chloride ions are generally absorbed by simple diffusion.

The passage of these substances into the blood depends upon the concentration gradients.

Some of the substances like fructose and some amino acids are absorbed with the help of the carrier ions like Na^+.

This mechanism is called the facilitated transport.

Transport of water depends upon the osmotic gradient.

Amino acids, monosacharides like glucose, electrolytes like Na^+ are absorbed into the blood.

Fatty acids and glycerol being insoluble, cannot be absorbed into the blood.

They are first incorporated into small droplets called micelles which move into the intestinal mucosa.

They are re-formed into very small protein coated fat globules called the chylomicrons which are transported into the lymph vessels (lacteals) in the villi.

The absorbed substances finally reach the tissues which utilise them for their activities.

This process is called assimilation.

The digestive wastes, solidified into coherent faeces in the rectum initiate a neural reflex causing an urge or desire for its removal.

The egestion of faeces to the outside through the anal opening (defaecation) is a voluntary process and is carried out by a mass peristaltic movement.

DISORDERS OF DIGESTIVE SYSTEM

Jaundice: The liver is affected, skin and eyes turn yellow due to the deposit of bile pigments.

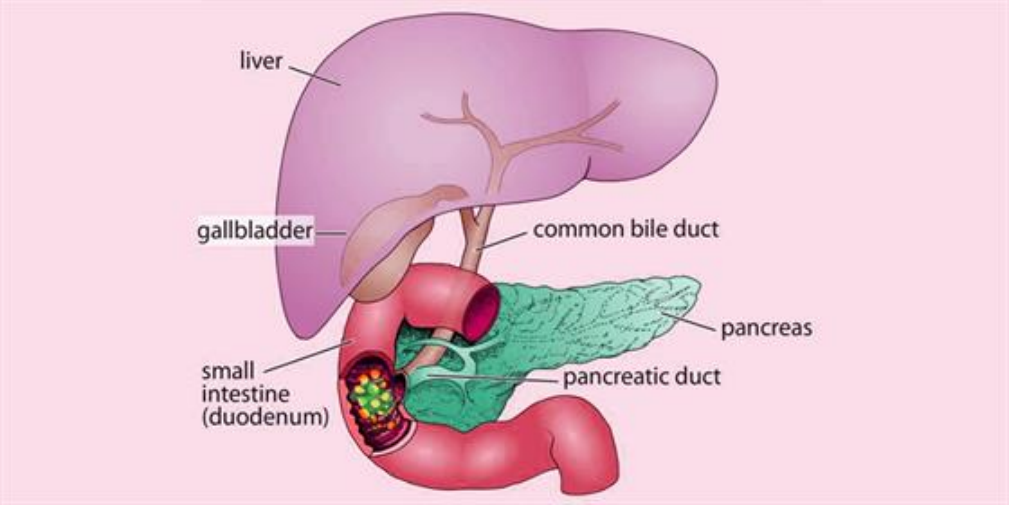
Vomiting: It is the ejection of stomach contents through the mouth. This reflex action is controlled by the vomit centre in the medulla. A feeling of nausea precedes vomiting.

Diarrhoea: The abnormal frequency of bowel movement and increased liquidity of the faecal discharge is known as diarrhoea. It reduces the absorption of food.

Constipation: In constipation, the faeces are retained within the rectum as the bowel movements occur irregularly.

Indigestion: In this condition, the food is not properly digested leading to a feeling of fullness. The causes of indigestion are inadequate enzyme secretion, anxiety, food poisoning, over eating, and spicy food.

Proteins play a vital role in the growth and replenishment of body cells and tissues.



IMPORTANT KEY POINTS

Acid reflux: a painful condition in which acids regurgitate from the stomach into the esophagus, also referred to as GERD (gastroesophageal reflux disease)

Anus: the opening of the rectum through which solid waste leaves the body

Bile ducts: a network that transports digestive fluids from the liver and gallbladder to the intestine

Colon: the main part of the large intestine

Digestive system: Comprised of the esophagus, small intestine, colon, rectum and anus

Duodenum: the first part of the small intestine

Esophagus: the muscular tube that connects the throat to the stomach

Gallbladder: the organ that works in conjunction with the liver and pancreas to assist with food digestion

Gallstones: a small mass in the gallbladder that blocks the bile ducts

Gastrointestinal: relating to the stomach and intestines

Sigmoid colon: the part of the large intestine close to the rectum and anus

Ulcers: a painful, open sore on the skin or a mucous membrane