

# Digestion: The System and Associated Glands

Cl 11 ch 16

# Contact me

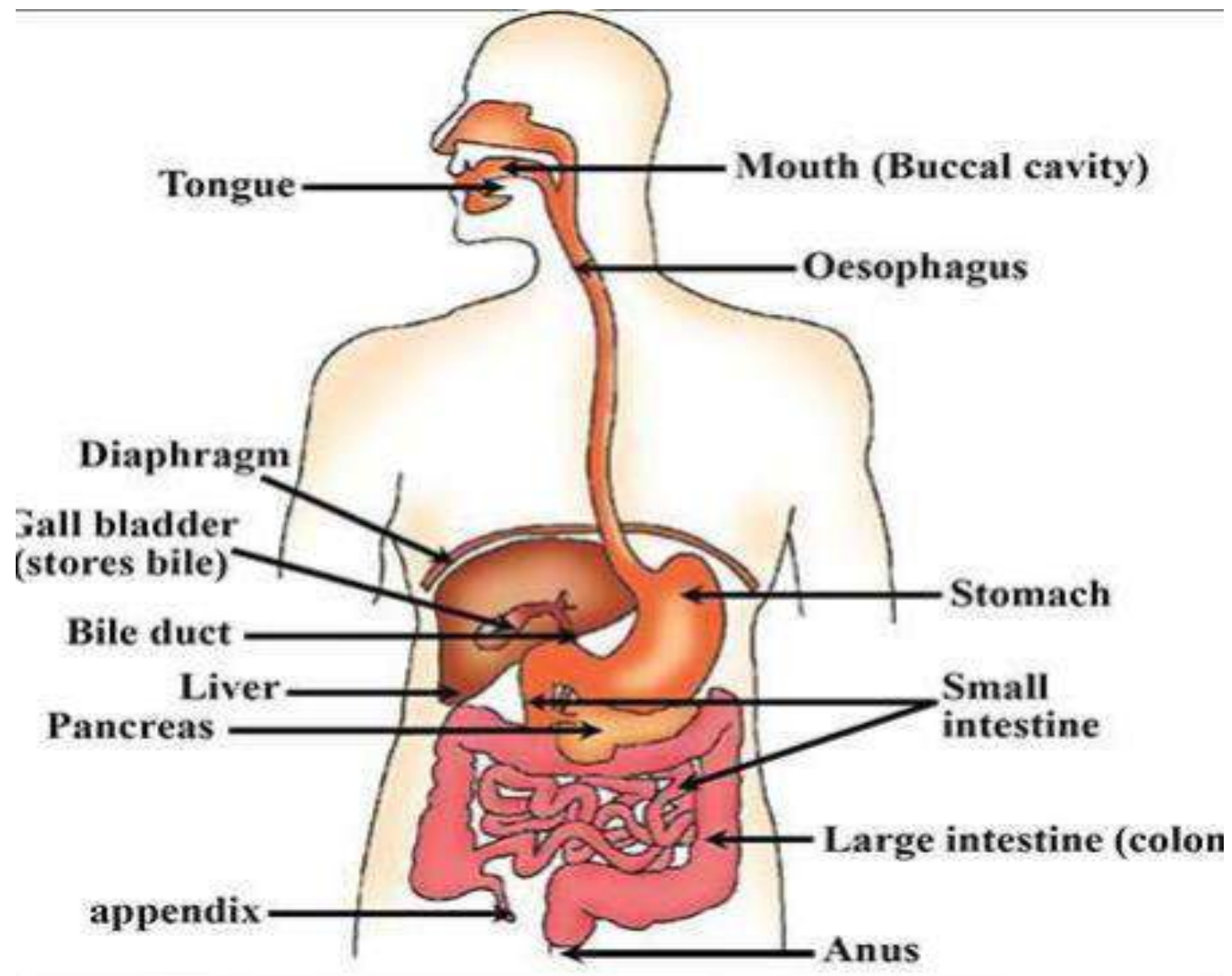
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- Animals depend on ready-made food for their nutritional requirements. Nutrition is a process by which animal obtain essential and non-essential substances called nutrients. The way by which organisms derive their nutrients is called mode of nutrition.

- (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., photoautotrophic and chemoautotrophic.
- (b) Heterotrophic The organisms which cannot use free energy of our atmosphere to synthesize necessary organic compounds as food. These normally obtain the nourishment from the autotrophs.

# Human digestive system

- 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.



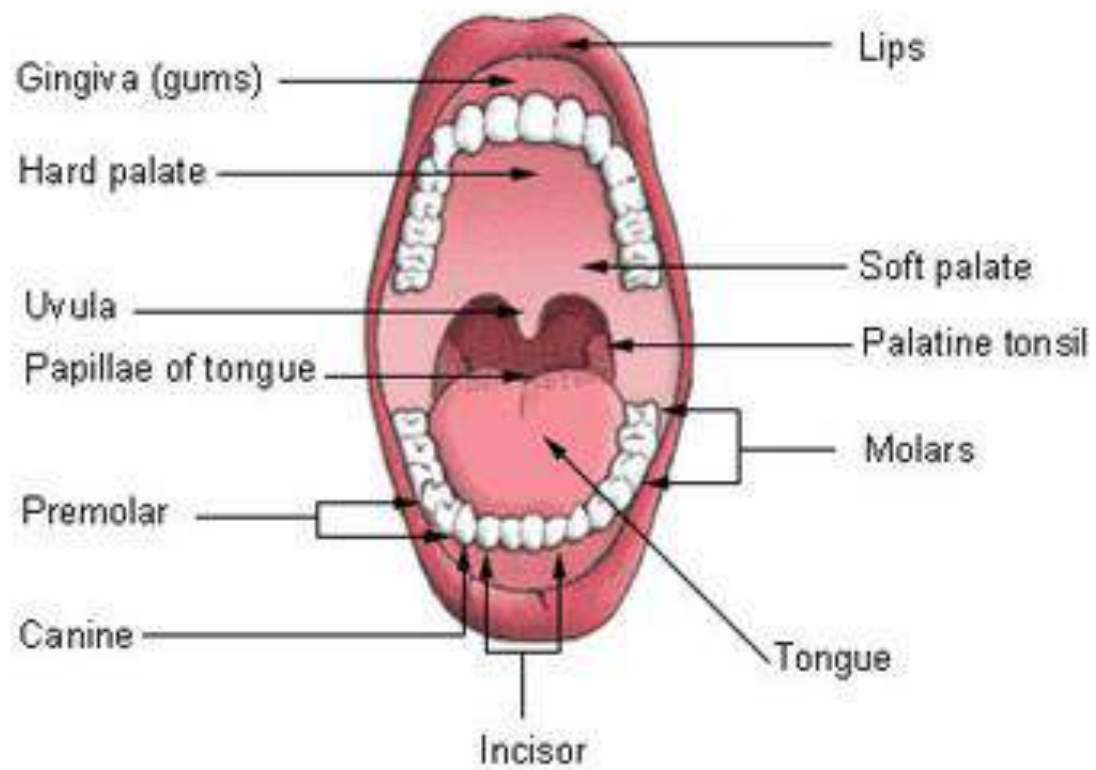
# Parts of Alimentary canal

- **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 in turn 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.

### **Mouth (Oral Cavity)**





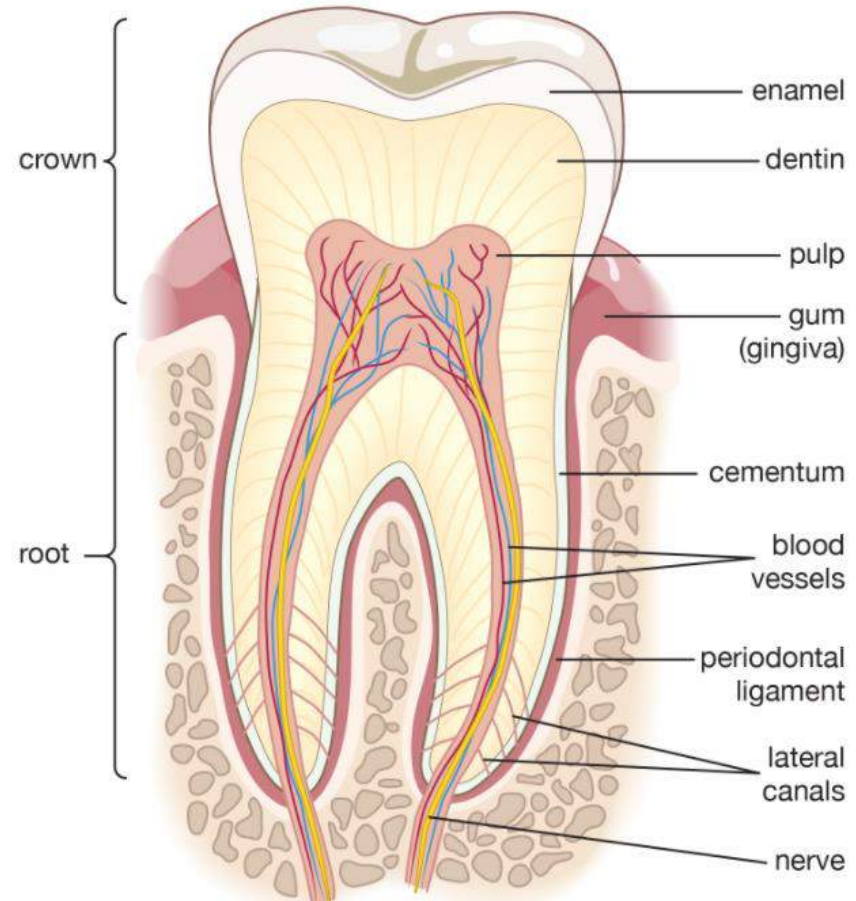
- **Thecodont** The teeth are fixed in sockets. They have very well-developed roots, which are implanted deeply in the jaw bone socket.
- **Diphyodont** Like other mammals, human beings also has two sets of teeth formed during lifetime. The first set of teeth is temporary and is known as milk or deciduous 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.

- **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.

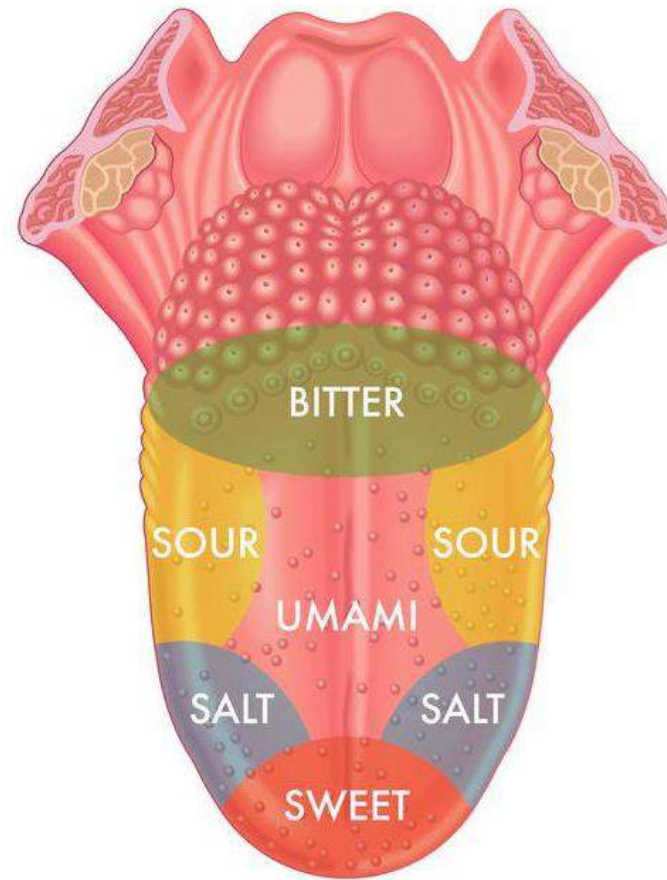
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- The hard visible chewing surface of tooth helps in the mastication of food and is covered by a thick, shiny and translucent substance called enamel (the hardest substance in the body).



- **Tongue**

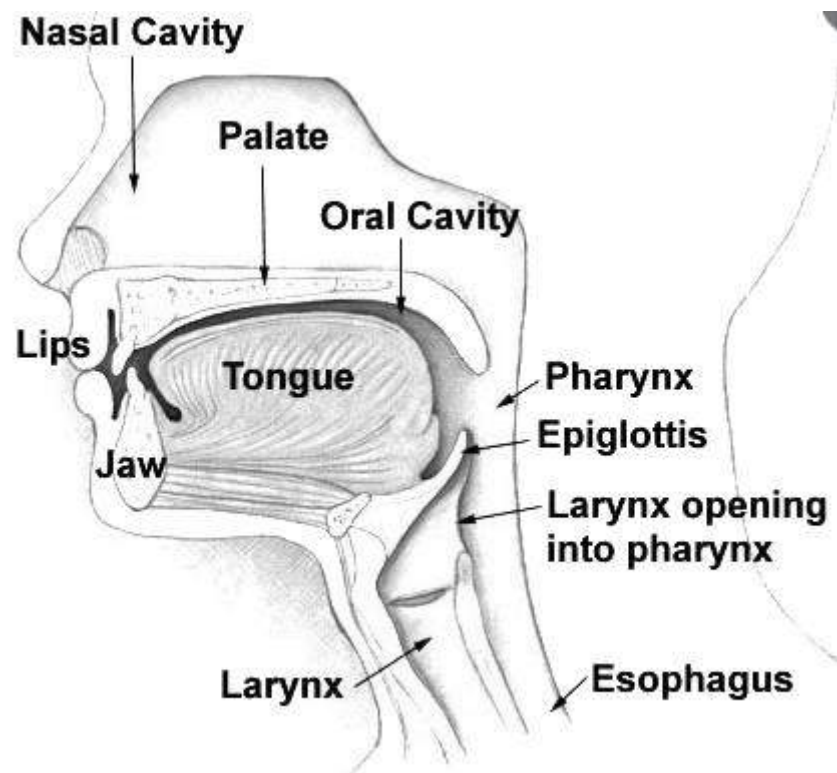
It is a muscular organ, which is freely movable in the oral cavity. A fold called frenulum attaches the tongue to the floor of oral cavity. The upper surface of the tongue bears small projections (elevations) known as papillae. Some of the papillae bear taste buds.



- **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.



- **Oesophagus**

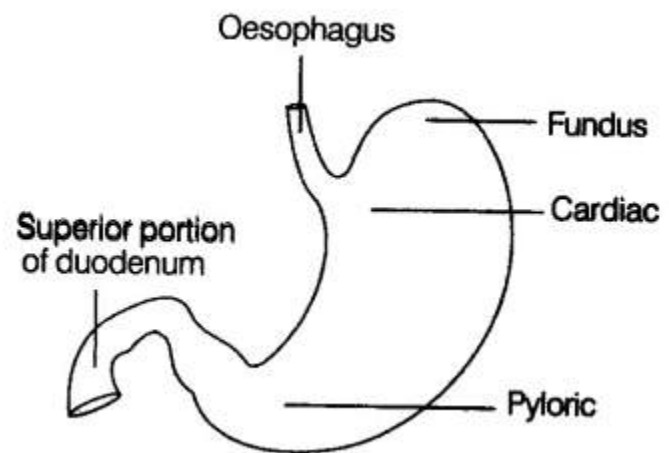
It is the thin, long muscular tube that extend posteriorly passing through the neck, thorax and diaphragm and finally leads into a J-shaped bag- like structure called stomach.

- A muscular gastro-oesophageal sphincter regulates the opening of oesophagus into the stomach.
- **Acid regurgitation**-Gastroesophageal reflux disease (GERD) occurs when stomach acid frequently flows back into the tube connecting your mouth and stomach (esophagus). This backwash (acid reflux) can irritate the lining of your esophagus.



- **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.



- **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.

- **Small Intestine**

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

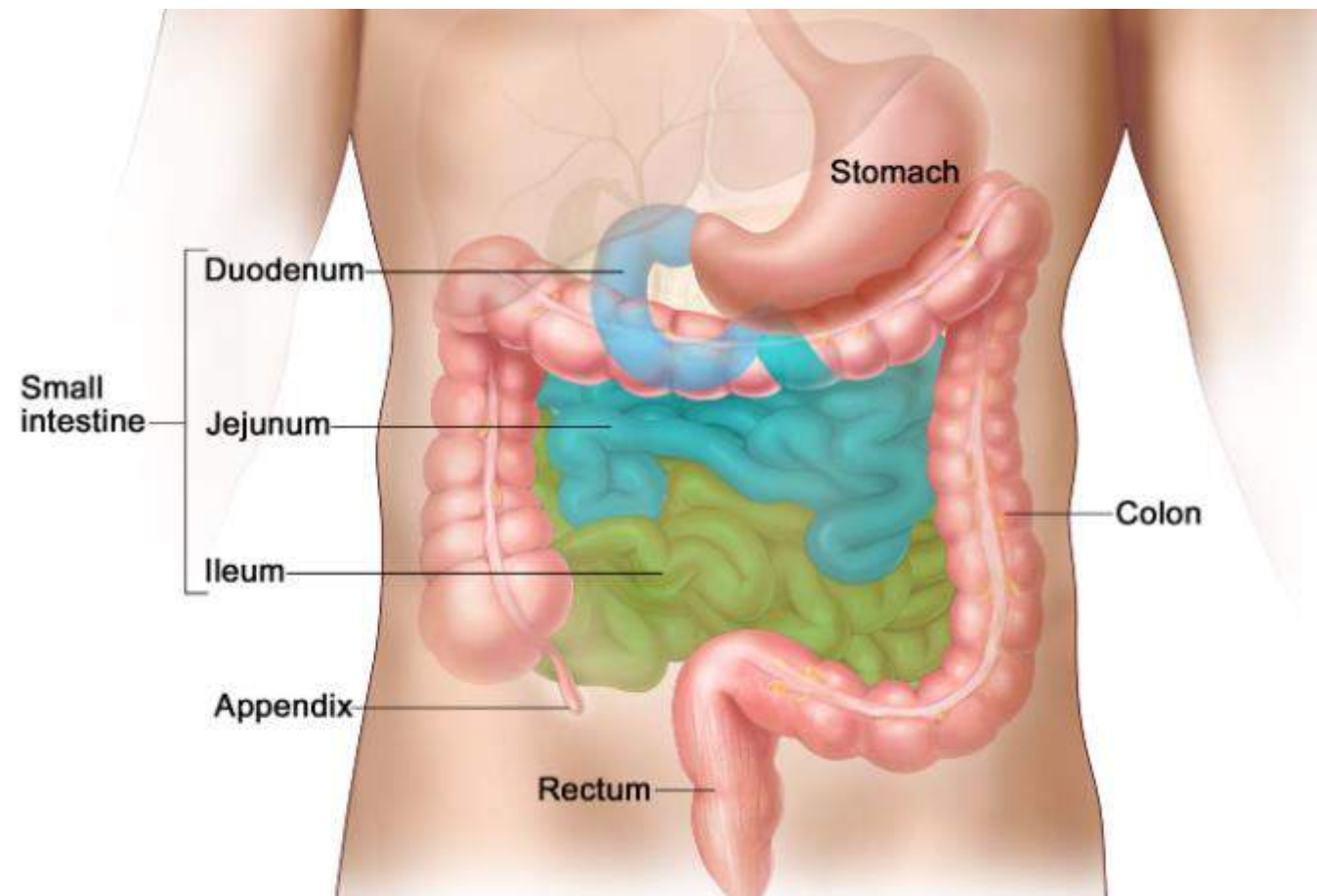
It is divisible into three main reports

(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.

- 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.



- (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

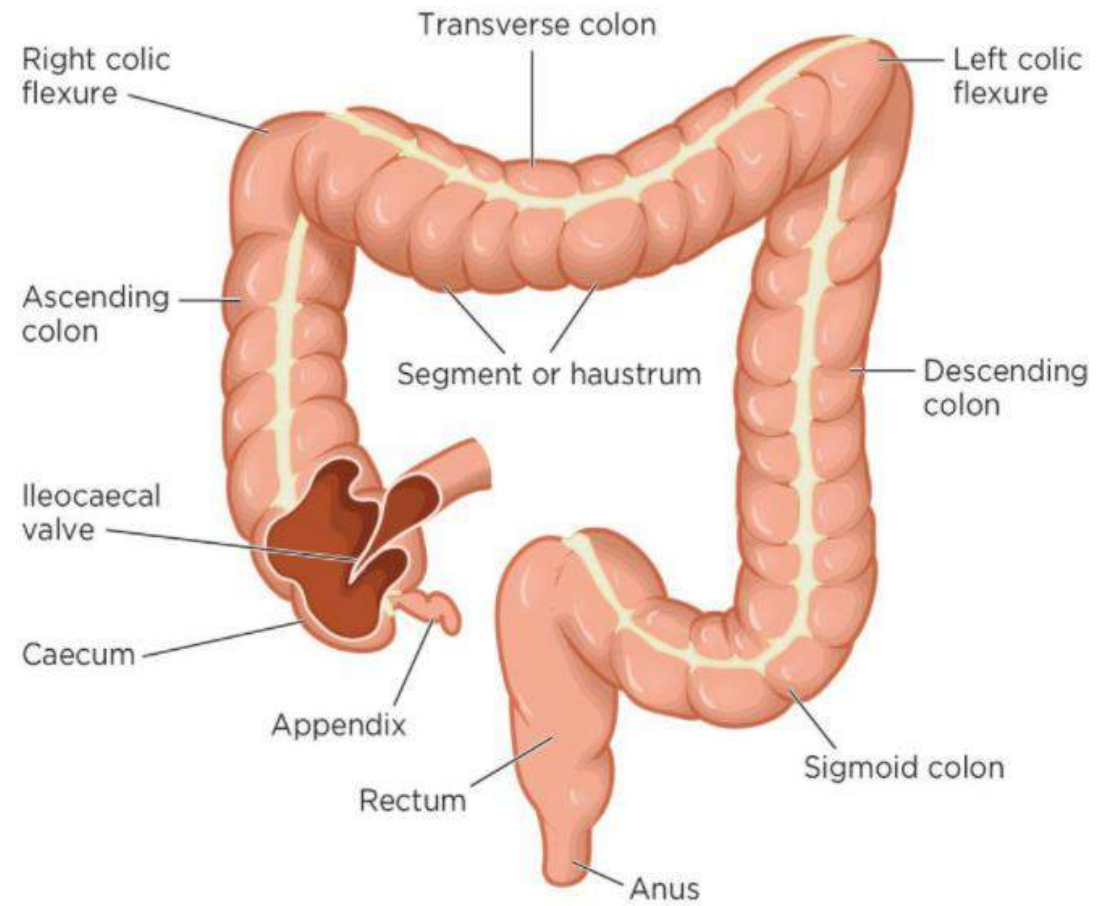
- **Large intestine**
- **lacks villi and microvilli**  
It is distinguishable into three main parts  
(a) **Caecum** It is a small pouch-like structure connected to the terminal part of small intestine. It is a blind sac that functions as a host for various symbiotic microorganisms. **Vermiform appendix**, 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.



- **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 valve is present, that regulates the passage of materials from small to the large intestines.



- **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.

- **Salivary Glands**

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These are exocrine glands that secrete 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.

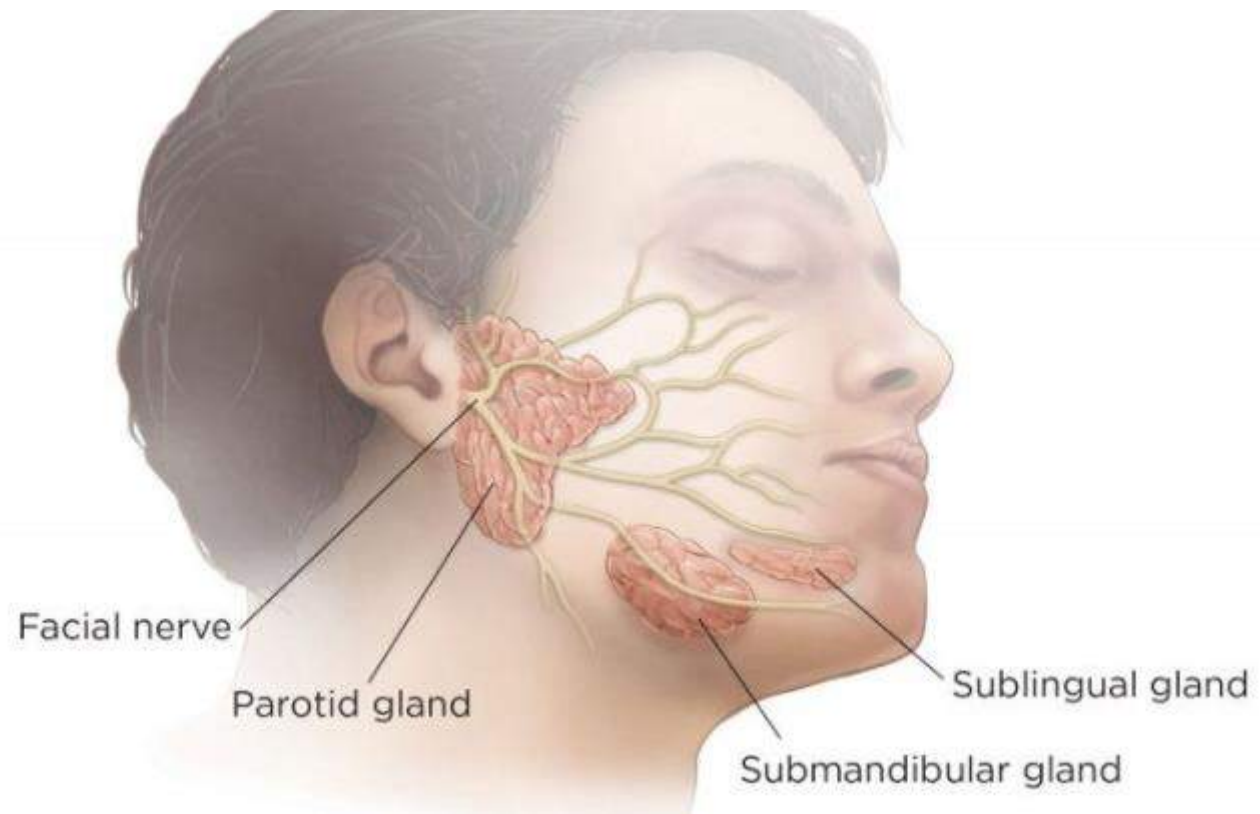
These are as follows:

(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.

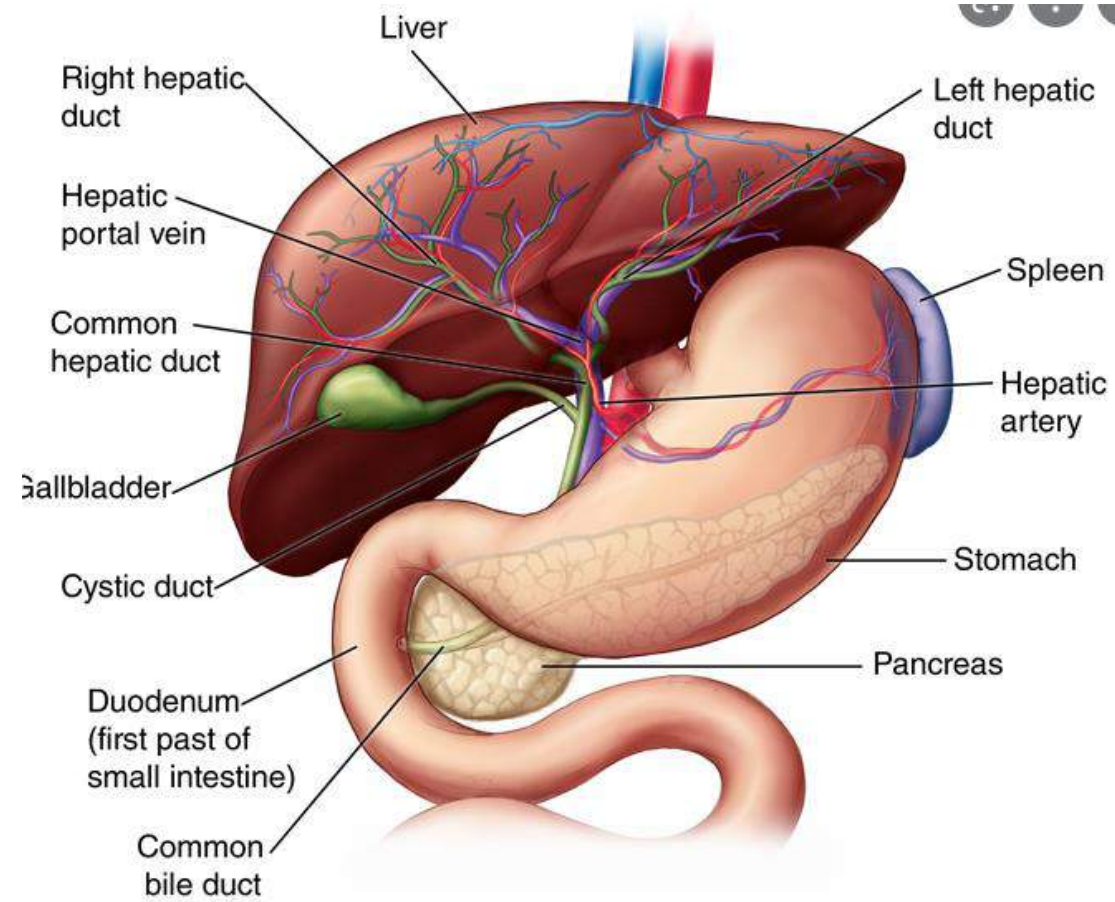
(c) **Sub-lingual Gland** These are situated beneath the tongue.

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



- **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 secrete the bile juice, which passes through the hepatic duct into the **gall bladder**.



- **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

- **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**.

- **Other Glands**

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

- Gastric glands
- Intestinal glands

- **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 ( chief or zymogenic cells, secretes inactive precursors of gastric enzymes.
- (c) Parietal or oxyntic cells, secretes HCl

- **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.

# Digestion

- 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

- **Buccal Cavity**  
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. 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.



- **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.

- **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 ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ , 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.

- **Digestion in Stomach**

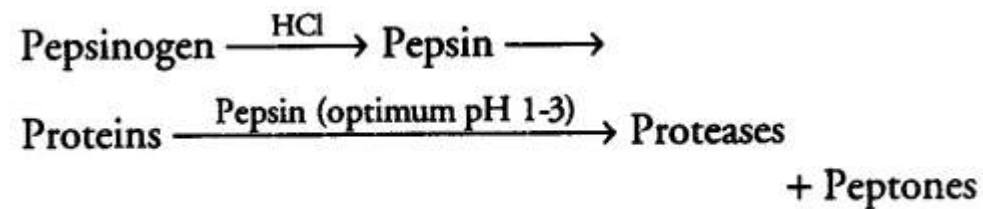
The stomach stores the food for around 4-5 hours. Internal mucosa of stomach contains gastric glands, which mainly comprises of three types of cells

- (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<sub>12</sub> 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.
- **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.

- **Digestion in Small Intestine**

- To further facilitate 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 small 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.

- **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<sub>12</sub>, also helps in absorption of calcium, magnesium and zinc (by increasing the acidity of colon region).

- **functions are performed 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 faecal 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  $\text{Na}^+$ ,  $\text{Cl}^-$ .

- **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.

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Thankyou