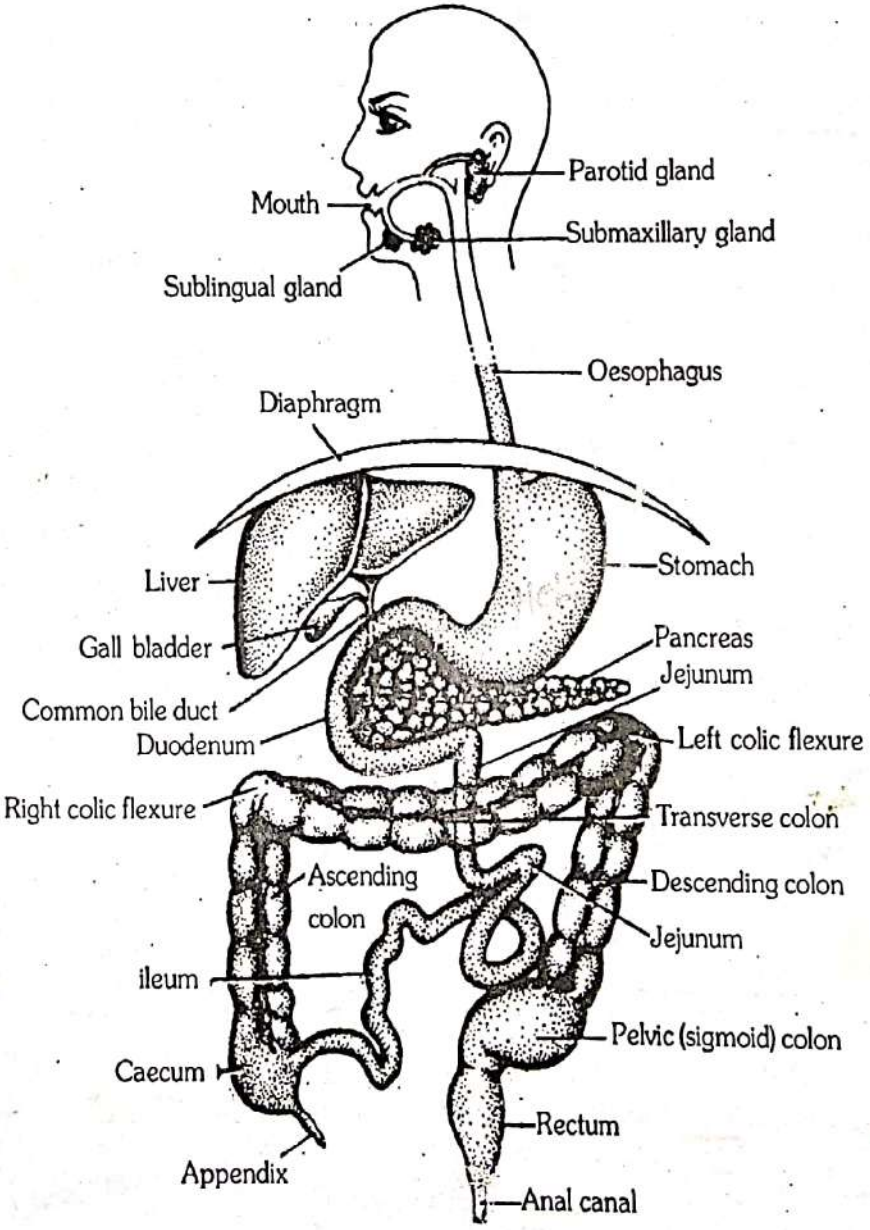
# DIGESTION AND ABSORTION

Food is one of the basic requirements of all living organisms. The major components of our food are carbohydrates, proteins and fats. Vitamins and minerals are also required in small quantities. Food provides energy and organic materials for growth and repair of tissues. The water we take in, plays an important role in metabolic processes and also prevents dehydration of the body. Biomacromolecules in food cannot be utilised by our body in their original form. They have to be broken down and converted into simple substances in the digestive system. This process of conversion of complex food substances to simple and absorbable forms is called **digestion** and is carried out by our digestive system by **mechanical and biochemical methods.**

**The general organisation of the human digestive system can be represented by following diagram.**




**Digestive tract of man**

**Origin**

The **alimentary canal** is tubular structure which **extends** from **mouth to anus.** It develops from and **endoderm.**

- Ectoderm - upto hard palate
- Endoderm - from soft palate to rectum
- Ectoderm - from anal canal to anus

## Digestive system of human

**Alimentary canal**
- Buccal cavity
- Oesophagus
- Stomach
- Intestine
  - **Small Intestine**
    - Duodenum
    - Jejunum
    - Ileum
  - **Large Intestine**
    - Caecum
    - Colon
    - Rectum

**Accessory digestive glands**
- Salivary glands
- Liver (with gall bladder)
- Pancreas

oily gland

Lip → outer → sebaceous gland
↳ inner → serous fluid → watery gla

**(1) Mouth and Buccopharyngeal Cavity –**

Mouth is a horizontal transverse slit like aperture which is surrounded by upper and lower lip, a specific is associated with lip called **orbicularis oris** muscle.

Serous Glands are also called Von Ebner's Glands

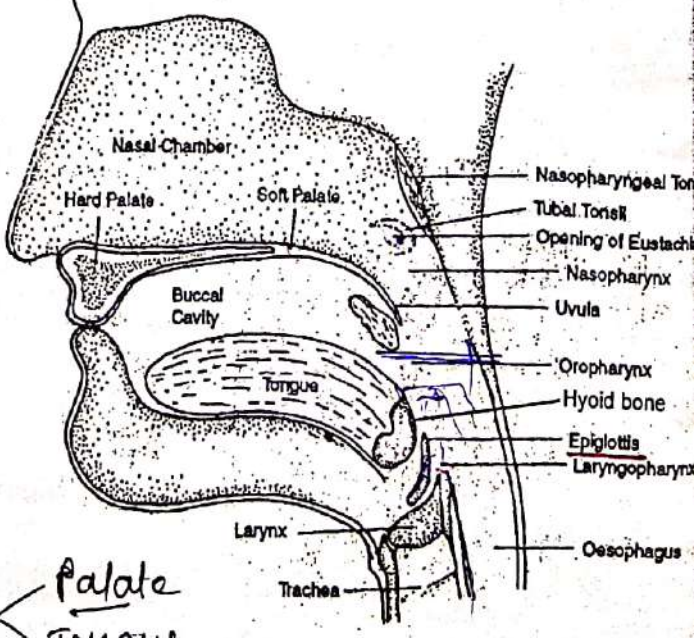
**Serous glands** are found on the **inner part** of **lip.** Serous glands is the modification of mucus glands. Its secretory substance is watery.

- Mouth opens into Buccopharyngeal cavity, this cavity is divided into two parts.

(i) **Buccal vestibule** – The space between the gums and cheeks where the food is stored temporarily for some time. It is a peripheral part.

(ii) **Main oral cavity** – It is inner and central part which is surrounded by upper and lower jaw, lined by stratified squamous epithelium.

Palate
Tongue
Teeth




**Section of head showing parts of pharynx**

**PALATE** → ① It also aids in eating and breathing together.

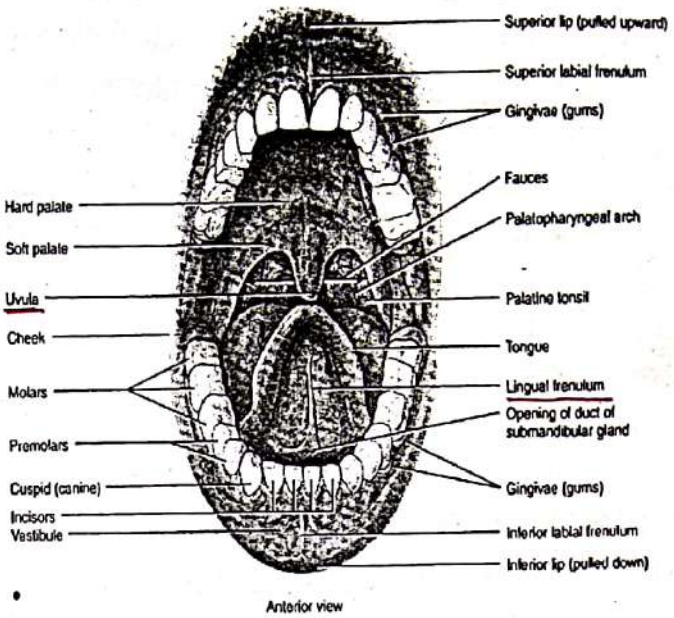
**Palate is differentiated into two parts :**

**(I) Hard Palate –**

It is the anterior part of the palate. It is **made up of maxilla and palatine bone** in human.

On the **ventral surface of hard palate,** some projection or transverse ridges are present which are called as **palatine rugae.**

These rugae prevent slip out of the food from buccal cavity during mastication, these rugae are well developed in carnivorous animals.



Anterior view

**(II) Soft Palate –**

It is the **posterior part of palate.** It is made up of involuntary muscle fibrous connective tissues and mucous epithelium. (Stratified squamous epithelium)

The **posterior out growth** of soft palate which hangs down in the form of finger like process called as **Uvula** or **Velum palati.** (আলজিভ)

On the **dorsal side of Uvula, internal nasal pores** are present.

**Uvula** or **Velum palati** covers the opening of internal nasal pores during ingestion of food, so food particle can not move inside nasal chamber.

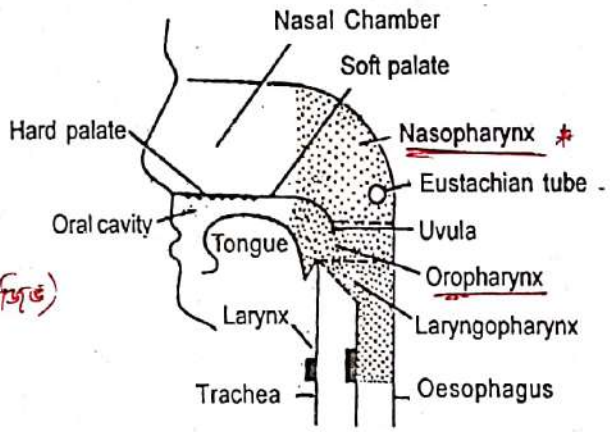


Diagram showing parts of pharynx

**Soft palate** is situated in the pharynx and is **divided** into two parts. **Upper part** of pharynx is called **Nasopharynx** which is related to the nasal chamber. The **lower part of pharynx** is called **oropharynx** which is related to the oral cavity. One pair of openings of **Eustachian tube** is present in the nasopharynx. This Eustachian tube is related to the **middle ear.** It **maintain air pressure.**

**Pharynx** is the common path for the air and food.

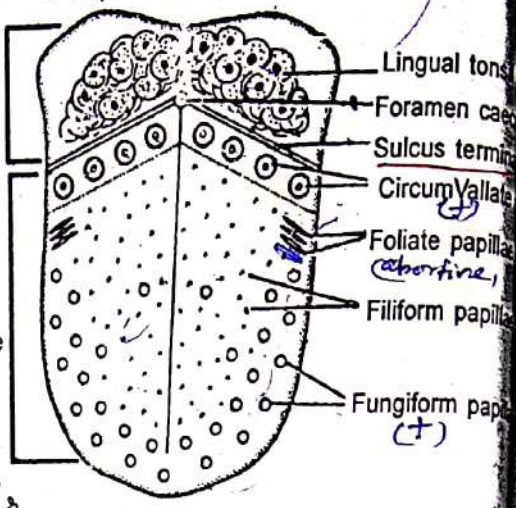
## TONGUE

Function → (swallowing → most imp.)
→ taste
→ speech
→ mixing with saliva
→ placing food in teeth

On the floor of oral cavity a muscular, flat, fleshy plate like structure is present which is called **tongue**.

* The anterior part of tongue is free while **posterior part of tongue** is connected to the **hyoid bone.**

* The **ventral surface of tongue** is connected to the floor of buccal cavity through a very flexible membrane/ ligamentous fold called as **frenulum linguae.**



Upper surface of human tongue (Dorsal)

* On the **dorsal surface of tongue,** it is divided into two unequal parts by a **V shaped sulcus,** called as **sulcus terminalis.**

* It is divided into two parts –

(I) **Pharyngeal part** – It is the posterior 1/3 part of the tongue.

(II) **Oral or papillary part** – It is anterior 2/3 part of tongue.

### MUSCLES OF TONGUE

**Extrinsic muscle :-**

It is found on outer and superficial part of tongue. It helps in outward and inward movement of tongue.

**Intrinsic muscle :-**

It is situated in the deep part of tongue. It helps in the change of shape of tongue.

### PAPILLAE

**Three types of functional papillae** are found in this part in which gustatory or taste receptors present in the form of **taste buds.**

(i) **Fungiform Papillae**

It is pink coloured, small and spherical in shape. It is found on the entire surface of tongue but present at the anterior part of tongue. It is attached to tongue with the help of small pedicle. It produces pink colour to the tongue.

(ii) **Filliform papillae (Conical papillae)**

They are thread like, white coloured and conical in shape. They are also found on the entire surface of tongue. They are **most numerous,** but **devoid of taste buds.**

(iii) **Circumvallate papillae**

It is largest and least existed papillae (8 to 12), they are large spherical shape papillae which are near to sulcus terminalis.

**Foliate papillae**

They are found on the mid lateral surface of tongue. They are **vestigeal** in the human.

**Function of Tongue :** Reception of taste.

nerves of mouth VII facial → Taste
IX Glossoph
- aryngeal
XII - Hypoglossal → movem
- ent-

# TEETH

Teeth are **ectomesodermal in origin.** Major portion of teeth arises from **dermis.** Part of tooth present outside the gums only is derived from or **epidermis (Enamel part)** ectoderm.

In human teeth are attached to the maxilla and mandible bone.

3 2 1 2 | 2 1 2 3
3 2 1 2 | 2 1 2 3

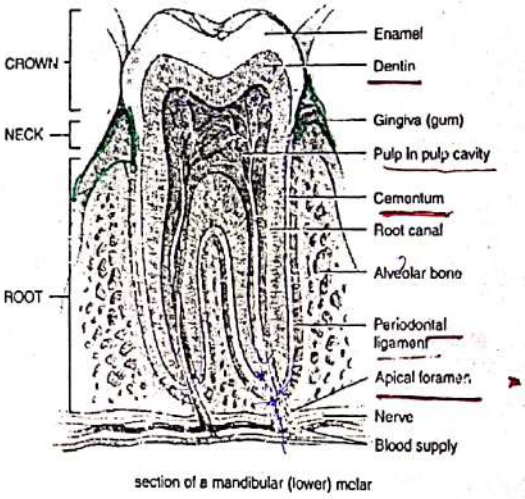
## STRUCTURE OF TEETH

Teeth are differentiated in three parts.

1) **Crown-** It is the outer part of the tooth, exposed **outside gums.**
2) **Neck-** It is the internal part of the tooth which is embeded **inside the gums.**
3) **Root-** It is the part of tooth that is inserted **inside the socket of jaw bone.** (Alveoli)

* The crown part of the tooth is covered with a very hard substance called the **enamel**. It is the hardest material in all animal of animal kingdom.
* Enamel is **ectodermal**. It is secreted by **ameloblast** cells of the ectoderm. It has **maximum** amount of **inorganic salt** (96%) in it. Inorganic salt are **mainly** found in the form of **phosphate and carbonate of $Ca^+$,** 3% of water is found in the enamel. Along with it amelogenin and enamelin protein (1%) are also found in teeth. Ossein is a protein of bones. **Remaining part of teeth** develop from **mesoderm** of embryo.

* **Dentine** is the **main part of tooth.** Approximately **69%** **inorganic salts** (hdyoxyapatite) are present in dentine where as in cemented layer **65% is inorganic salt (62% inorganic salts are present in bones.)**



section of a mandibular (lower) molar

* Dentine surrounds a cavity called **pulp-cavity.** This cavity contains soft connective tissue, blood capillaries, nerve fibres. Pulp cavity is necessary for the nutrition and survival of the teeth. At the base of pulp-cavity an aperture is present. Through this aperture, blood capillaries and nerve fibres enter inside the teeth. This aperture is called **apical-foramen.**
* A special type of cells form the lining of the pulp-cavity called the **odontoblast cells**. These cells are the dentine secreting cells. Cytoplasmic process of odontoblasts are embedded into dentine in the form of fine tubule. These processes are called **canaliculi**. The teeth continue grow till the odontoblast cells remain active. In adults, the pulp-cavity shrinks and the odontoblasts become inactive so the teeth stops to grow.
* The cement layer is made up of the **cementocytes cells**. Between the root and the bones of the teeth, a periodontal membrane is present.

**Four types of teeth found in mammals are -**

**Incisor-** These are long, **chisel like teeth for gnawing** the food. They are more developed in gnawing animals e.g. lagmorphs, rodents. **Tusk of elephants** are modification of **upper incisors.**

**Canines-** These are **sharp pointed** teeth meant for tearing and shearing the food. Canines are mo oped in carnivorous animals. Canines are absent in herbivorous animals e.g. Rabbits do not have ca herbivorous, the **space of canine in gums** is empty and this empty space is called **diastema.**

**Premolars -** These teeth are meant for **chewing and crushing of food.** they are triangular in shap

**Molars** (Cheek teeth) – These also meant for **chewing and crushing of food.** They are rectangular in Premolar and molar help in the mastication of food.

In mammals, except premolar and last molar, all type of teeth appear twice in life. Teeth which appear childhood are called **milk teeth/temporary teeth/lacteal teeth/deciduous teeth/primary teeth** the activity of osteoclast cells These milk teeth are shed, then permanent teeth appear.

**Hippocampus, tortoise and birds do not have teeth.**

## TYPE OF TEETH

### ON THE BASIS OF APPEARENCE IN LIFE :-

**Monophyodont** :- The teeth which appear only once in life. eg. **Premolars and last molars of man**

**Diphyodont** :- The teeth which appear twice in life. eg. **Incisors, Canines, 1st and 2nd molars.**

**Polyphyodont** :- The teeth which appear more than twice in life. eg. **Fish, Amphibians.**

### ON THE BASIS OF ATTACHMENT OVER JAW

**Thecodont** :- The teeth which are present in bony socket of Jaw. eg. **Man and Crocodile.**

**Pleurodont** :- The teeth which are present on the lateral side of Jaw bone. eg. **Reptiles.**

**Acrodont** :- The teeth which are present on the terminal part of Jaw bone. eg. **Fish, Amphibian**

### ON THE BASIS OF STRUCTURE AND FUNCTION

**Hetcrodont** :- When the teeth are of different type in mammals on the basis of structure and function.

eg. Mammals.

**Homodont** :- Whether all teeth are of similar type in animal on the basis of structure and function.

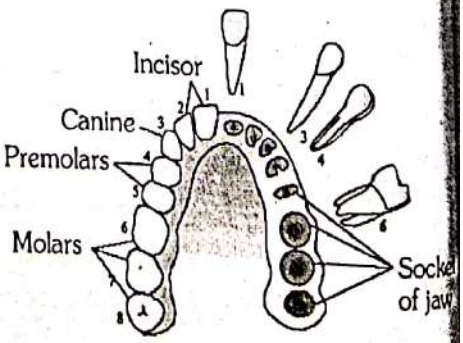
eg. **Fishes, Amphibians.**

**Dental formula :-**

Child = $I\frac{2}{2}C\frac{1}{1}PM\frac{0}{0}M\frac{2}{2} = \frac{5}{5} \times 2 = \frac{10}{10} = 20$

17 Yr. old = $I\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{2}{2} = \frac{7}{7} \times 2 = 28$

Adult = $I\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{3}{3} = \frac{8}{8} \times 2 = \frac{16}{16} = 32$




**Arrangement of different types of teeth in the jaws on one side and the sockets on the other side**

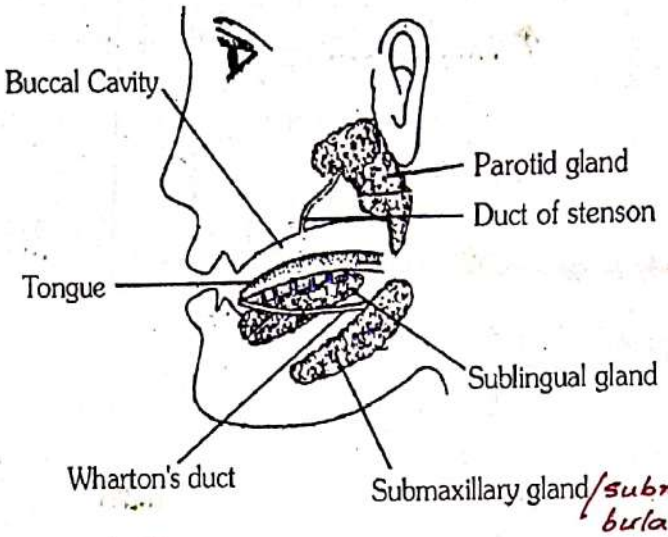
## ARY GLANDS

In human three pairs of salivary glands are present. These are situated outside the buccal cavity.

**Parotid glands :** These are largest salivary glands. These glands are located just below the auditory capsule (ear). Their duct is called **Parotid duct/Stenson's duct** which **open in the vestibule of the upper jaw** i. e. the buccal vestibule. Whenever in human, these glands are **infected by viruses** this disease is called as **mumps.** Due to this, the gland swells up.

**Submaxillary or Submandibular glands-**

These are located **at the junction of the upper and the lower jaw.** Their duct is called **Wharton's duct** (largest salivary duct). These **ducts open** in the **lower jaw** just **behind the incisor teeth. Maximum saliva** is secreted by the **Sub-maxillary glands**. Salivary glands are **exocrine** glands. The secretion of salivary glands are termed as the saliva.




**Sublingual glands:** These are the smallest salivary glands. These glands are found in the lower jaw. Many ducts arise from these glands called as the **ducts of Rivinus** or **Bartholin's ducts.**

These ducts **open** in the bucco-pharyngeal cavity **on the ventral side of the tongue.**

**Composition of saliva :**

Water-99.5 %

Mucus , starch -digesting **Ptyalin enzyme**, lysozyme and thiocyanates and few ions like sodium, potasium, chloride, **IgA** antibody, **urea** and uric acid etc., are present.

Majority of **ptyalin** is secreted by the parotid glands. Ptyalin is activated by $Cl^-$

**Lysozyme** and **thiocyanates** mainly kill bacteria. They also check the growth of bacteria in bucco-pharyngeal cavity.

Salivation is stimulated by cranial nerve VII and IX.

**Waldeyer's Ring** (Waldeyer's Ring)

Lymphatic tissue of pharynx is called Tonsil.

The lymphatic tissues of the pharynx are arranged in a ring like manner, collectively called Waldeyer's ring.

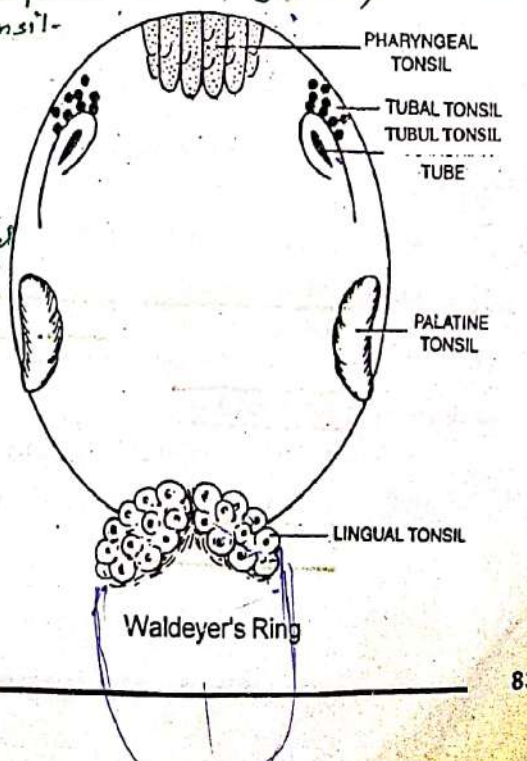
The ring mainly consists of the following:

(i) **Nasopharyngeal Tonsil ( Adenoid)** swelling may cause of obstruction to normal breathing. (pharyngeal tonsil).

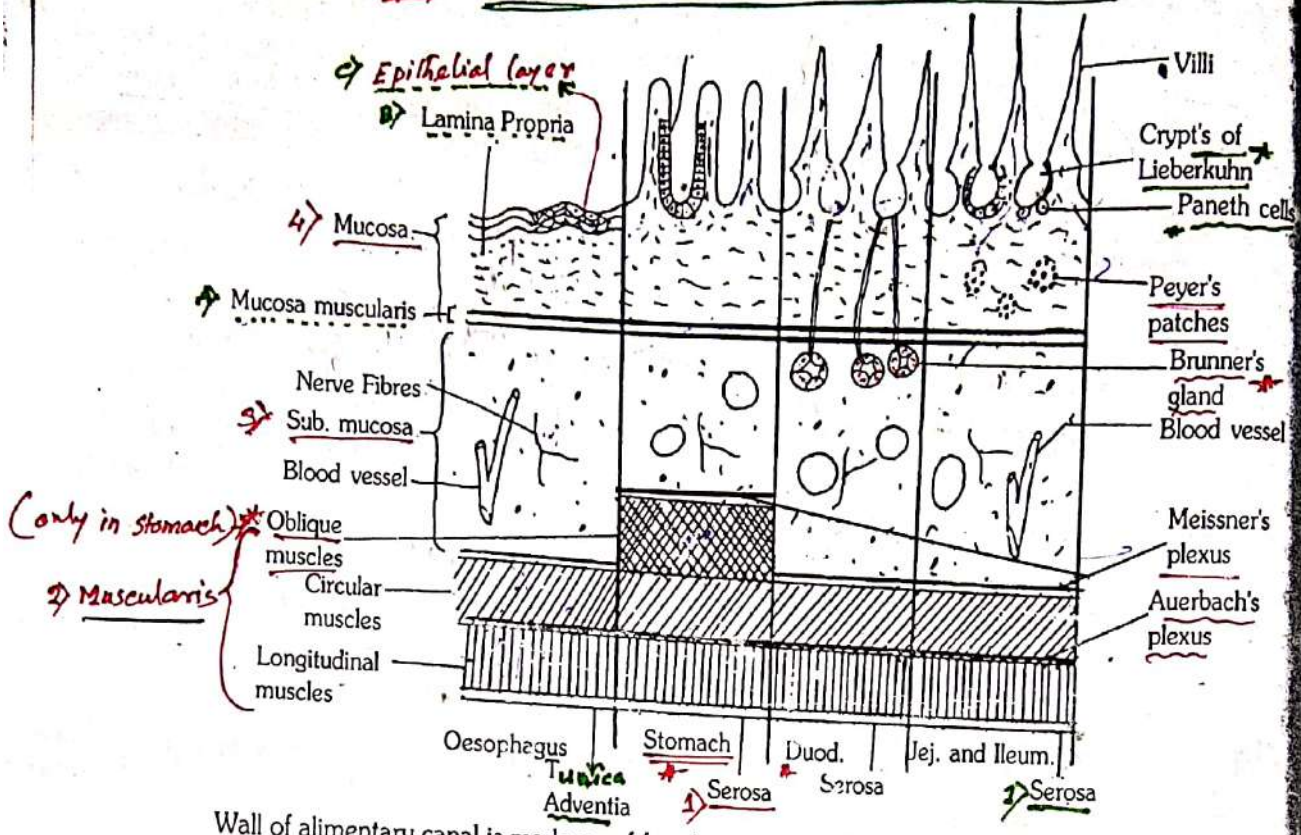
(ii) **Tubal Tonsil :-** Present around the opening of eustachian tube.

(iii) **Palatine Tonsils** (=Faucial Tonsils) **:-** The palatine tonsils are often infected **(tonsillitis)** leading to sore throat. Such enlarged tonsils may become a focus of infection and their surgical removal **(tonsillectomy)** becomes necessary.

(iv) **Lingual Tonsil :-** They are situated on posterior part of tongue.



# HISTOLOGY OF ALIMENTARY CANAL




Wall of alimentary canal is made up of four layer (outer to inner)

**(1) Serosa :** It is outer most layer of gut, serosa (= visceral peritoneum) is composed of areolar simple squamous epithelium (= mesothelium). Some part of gut is lined with tunica adventitia made up of areolar connective tissue only.

**(2) Muscle layer / Muscularis :—**

(i) It is formed by circular inner layer and longitudinal outer layer of smooth muscle.

(ii) Thickest layer is found in stomach (maximum peristalsis) and thinest layer in rectum (minimum peristalsis)

(iii) Stomach contains an additional oblique muscle layer just interior to circular muscle.

**(3) Sub mucosa :** It is composed of areolar connective tissue layer with blood vessels, lymph vessels and also present in duodenum (e.g.- Brunner's gland)

**(4) Mucosa :** It is the innermost layer of gut which contains the secretory and absorptive cells.

Mucosa is differentiated into 3 layers.

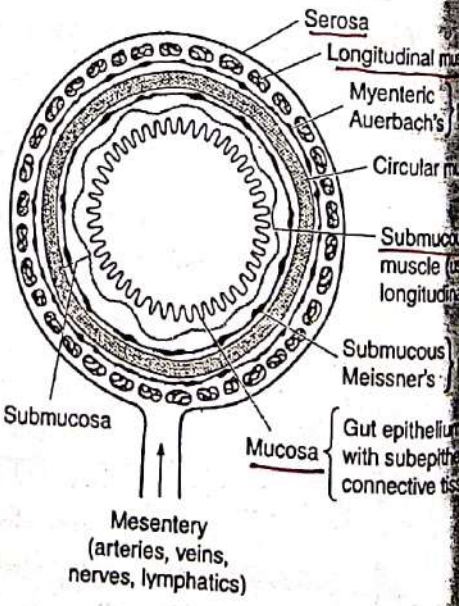
(i) **Outer layer** (towards submucosa) is called **mucosa muscularis.**

- It is made up of smooth muscles.
- It has important role in exposing of surface area for the absorption
- They also provide support to the folds of mucosa.

(ii) **Middle layer** is **lamina propria** it contains lymphatic tissues refers as **MALT** (=Mucosa Associated Lymphoid Tissue) which provides immunity ex. peyer's patches .

- It is made up of **areolar connective tissue.**

(iii) **Innermost layer** (in contact of food) is **epithelial mucosa.**




**Cross section of alimentary canal**

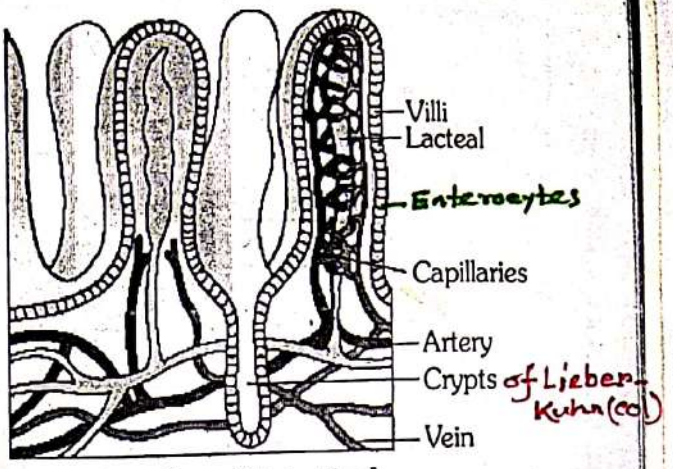
In oesophagus this layer is made up of **non keratinised stratified squamous epithelium.**

**Except oesophagus** this layer is single layer thick, which is made up of **columnar mucous epithelium.**

Folds of oesophagus are less developed, where as folds of stomach are finger shaped and develop as gland called **gastric gland.**

Folds of small intestine are conical shaped called **villi.**

Small slit like space is found at the base of villi. These spaces are called **Crypts of Lieberkuhn(COL).**



**A section of small intestinal mucosa showing villi**

Villi of duodenum are small blunt.

Villi of jejunum and ileum are long and pointed.

**Maximum villi are found in Jejunum.**

**Brunners gland (submucosal or duodenal gland) :-**

They are small spherical multicellular glands.

They open into crypts of lieberkuhn with the help of fine tubules.

These glands are found in the **submucosa of duodenum.**

They secrete the non enzymatic alkaline mucus to protect the duodenal epithelium from HCl.

**Paneth cells :-** (Paneth cell)

These cells are found in **Crypts of Lieberkuhn of mucosal layer** of small intestine. (in Jejunum & Ileum)

They are unicellular glands.

These cells **secrete defensin and lysozyme** hence it provides immunity.

**Peyer's patches :-** (Intestinal Tonsil)

They are aggregated lymph nodes which are found in the mucosa of small intestine (Ileum). They are also called as intestinal tonsils.

**nteric nervous system** [The layers of Alimentary canal have network of nerve fibres called PLEXUS]

Two types of nerve plexus are found in muscle of alimentary canal.

i) **Auerbach's nerve plexus** (= myenteric plexus) this nerve plexus is found between longitudinal muscles and circular muscles, it start muscles contraction to initiate peristalsis.

ii) **Meissner's nerve plexus** (= submucosal plexus) found between circular muscles and submucosa but in stomach it is found between oblique muscle and submucosa, it regulate the secretion of epithelial mucosa.

## OESOPHAGUS

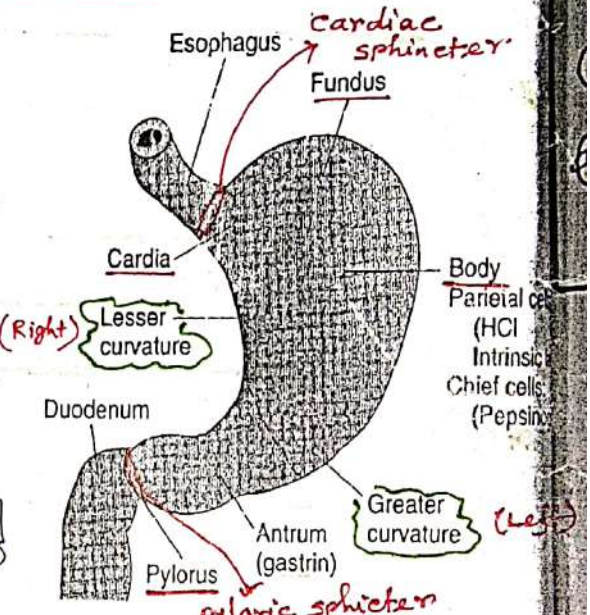
- Oesophagus is simple uniform tube which runs downward and pierces the diaphragm and finally o stomach that site of piercing on diaphragm is called **hiatus**.
- Voluntary muscles are found on the upper 1/3 part of oesophagus while mid 1/3 part is formed by and involuntary muscles where as in lower 1/3 part of oesophagus only involuntary muscles are pre
- It lacks serosa, but tunica adventitia is present. (in the 1st part of oesophagus)

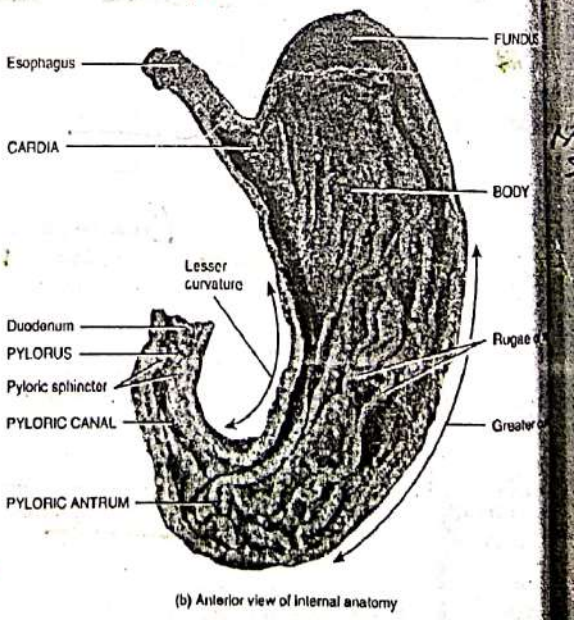
Two apertures are found in central part of buccopharyngeal cavity.

- Ventral or lower aperture is called **glottis** which is **related to the larynx,** which is guarded by **epiglottis** **cartilagenous flap).** (স্বরযন্ত্র)
- The dorsal and upper aperture is called **gullet** which opens into the oesophagus.

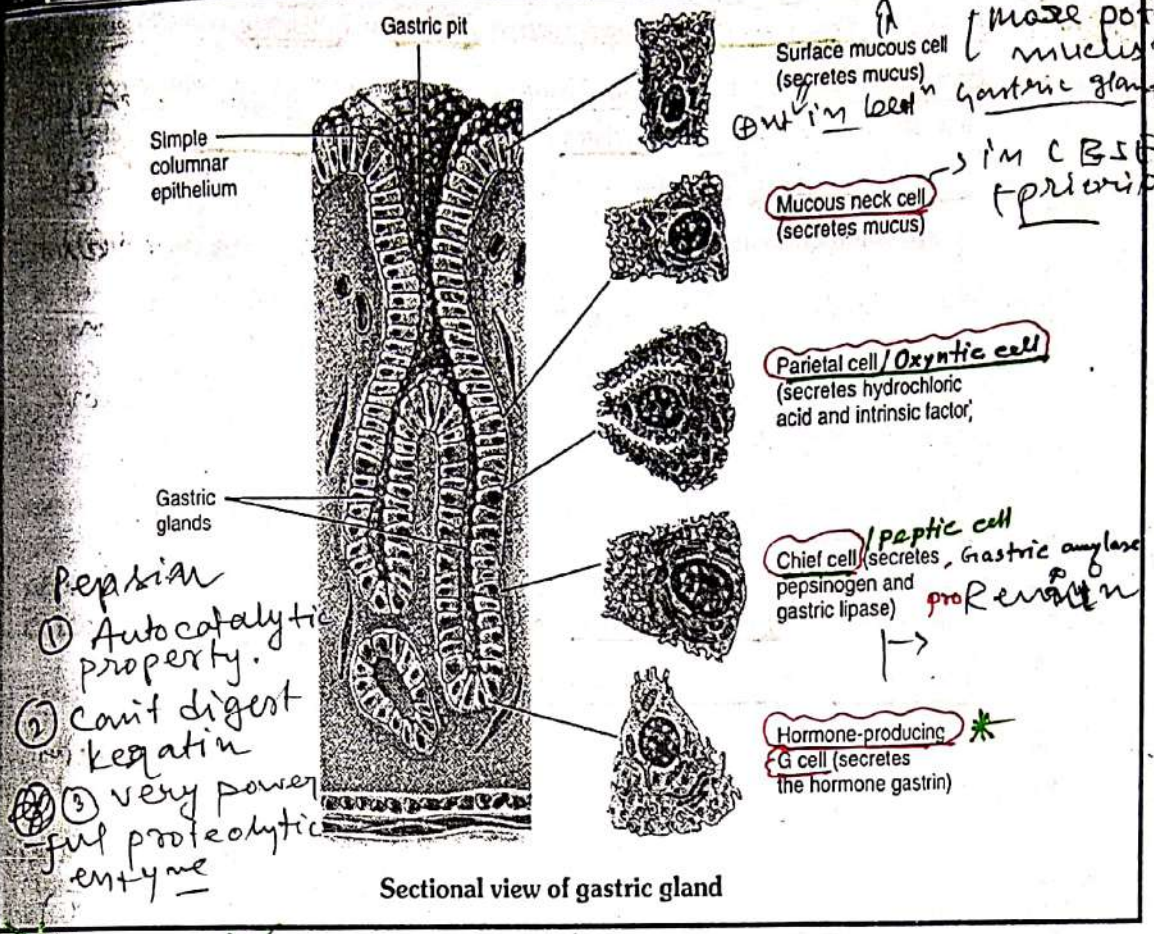
## STOMACH

- It is situated on left side of abdominal cavity. **It is the widest part of alimentary canal.** It is a bag like muscular structure, **J shaped in empty condition.**
- The stomach contains following parts – **Cardia, Fundus, Body, Pylorus.**
- It has two orifices (opening)
- (i) **Cardiac orifice** is joined by the lower end of the oesophagus.
- (ii) **Pyloric orifice** opens into the duodenum.
- Stomach is covered by layer of peritoneum. Fat tissues and lymph tissue deposits on the peritoneum.
- Such type of peritoneum are called Omentum. greater curvature attached with more deposition of lymph tissues and fat.
- Left curved surface of stomach is called greater ommentum. Right curved surface of stomach is called lesser curvature, attached with less lymphy tissue and fat lesser omentum.
- The stomach stores the food for 4-5 hours. The food mixes thoroughly with the acidic gastric juice of the stomach by the churning movements of its muscular wall and is called the **chyme.** The mucus and bicarbonates present in the gastric juice play an important role in lubrication and protection of the mucosal epithelium from excoriation by the highly concentrated hydrochloric acid. HCl provides the acidic pH (pH 1.8) optimal for pepsin.




(b) Anterior view of internal anatomy




**Sectional view of gastric gland**

**Gastric Glands :-** These are numerous microscopic, simple tubular glands formed by the invagination of epithelium in the stomach. The following types of cells are present in the epithelium of the gastric glands.

**i) Chief cells or Peptic cells** (=Zymogen cells)

They are usually **basal** in location and secrete gastric digestive enzymes as proenzymes or zymogens called **pepsinogen** and **prorennin**.

The chief cells also produce small amount of **gastric amylase** and **gastric lipase**. Gastric amylase action is inhibited by the highly acid condition.

Gastric lipase contributes little to digestion of fat (unemulsified).

Prorennin is secreted in young mammals (Childhood stage). It is not secreted in adult mammals. Rennin is a proteolytic enzyme found in gastric juice of infants which helps in the digestion of milk proteins.

**ii) Oxyntic cells** (=Parietal cells) are large and are most numerous on the side walls of the gastric glands.

They are called oxyntic cells because they stain strongly with eosin dye. They are called parietal cells as they lie against the basement membrane. They secrete **hydrochloric acid** and **Castle's intrinsic factor**.

**iii) Mucous neck cells** are present through out the surface epithelium and secrete **mucus**.

**iv) Enteroendocrine cells** or **argentaffin cells** are usually present in the basal parts of the gastric glands, which is differentiated in three cells - these cells are **D-cells, Enterochromaffin like cells (ECL-cells)** and **G-cells.**

In stomach 3 types of Glands are found— i) Cardia Gland → secretes mucus in cardia region, ii) Pyloric Gland — secretes mucus in pylorie region iii) Fundic Gland — It secretes Gastric juice.

**D-cells** secrete somatostatin, **ECL-cells** secrete serotonin and histamine, where as **G-cells** secrete gastrin.

- Somatostatin suppresses the release of hormones from the digestive tract. Serotonin is a vasoconstrictor stimulates the smooth muscles. Histamine dialates the walls of blood vessels. Gastrin stimulates glands to release the gastric juice.

**Composition of Gastric juice :**

Water = 99.5%

HCl = 0.2 - 0.3%

pH = 1.5 to 2.5 (very acidic)

rest = mucus water, HCl and gastric enzymes (Pepsinogen, Prorennin, Gastric lipase etc.).

**Functions of HCl –**

1. The main function of HCl (activater) is to convert inactive enzymes (zymogens) into active enzymes.

Pepsinogen and Prorennin are inactive enzymes.

Pepsinogen $\xrightarrow{HCl}$ Pepsin.

Prorennin $\xrightarrow{HCl}$ Rennin.

2. It destroys all the bacteria present in the food.
3. HCl stops the action of saliva on food. In stomach, the medium is highly acidic.
4. It dissolves the hard portions of the food and makes it soft.

## INTESTINE

It is divided into two part

(i) Small intestine (ii) Large intestine

## SMALL INTESTINE

- Small intestine is differentiated into three part

(i) Duodenum (25 cm.) (ii) Jejunum (1 m.) (iii) Ileum (2 m.)

- **Duodenum is retroperitoneal** and initial part of small intestine. Duodenum is the shortest, widest and fixed part of the small intestine.

For the efficient absorption of digested food large surface area is required. Therefore some adaptations present here.

(1) Great length of the intestine.

(2) The presence of permanent deep folds in mucosa is called **plicae circularis, valvulae conniventes/valves of kerckring.**

(3) Villi

(4) Microvilli

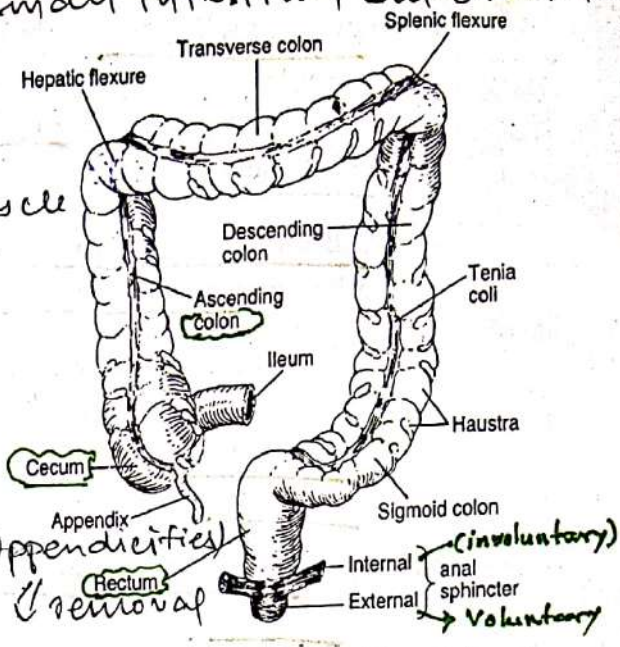
pH of intestinal juice = 7.6

## GE INTESTINE

Large intestine (Larger in diameter) – Large intestine is differentiated into three parts **caecum, colon and rectum.**

### CAECUM

The lower end of the ileum opens at **Ileo-caecal junction**. The Ileocaecal opening is guarded by **Ileocaecal valve.** Caecum is a small blind sac. About 2 cm below the ileocaecal orifice, a worm like structure arises from the caecum called as **vermiform appendix.** Its length varies from 2 to 20 cm. It is a vestegial organ. **(Caecum is well developed in rabbit** and not well developed in human).




### COLON

The diameter of the colon is greater than that of the small intesine. Its length is about 100 cm in living adults and about 150 cm at autopsy. The fibers of its external muscular layer are collected into three longitudinal bands, the teniae coli. Because these bands are shorter than the rest of the colon, the wall of the colon forms outpouchings (haustra) between the teniae (Fig.) There are no villi on the mucosa. The colonic glands are short inward projections. The movement of colon include segmentation contractions and peristaltic waves like those occuring in the small intestine. A third type of contraction that occurs only in the colon in the mass action contraction. Colon of human has ascending, transverse and descending part.

### RECTUM

This colon then continues in a uniform tube called **rectum.** (Storage chamber for faeces)

Rectum open into a small bag like structure called **anal-canal.** Piles **(Haemorrhoids)** is local enlargement of rectal vein.

Anal canal opens outside by **anus**. Anus is controlled by anal sphincter.

Two types of anal sphincter are found at the opening of anus..

Internal anal sphincter is involuntary while external anal sphincter is voluntary.

# ACCESSORY DIGESTIVE GLANDS

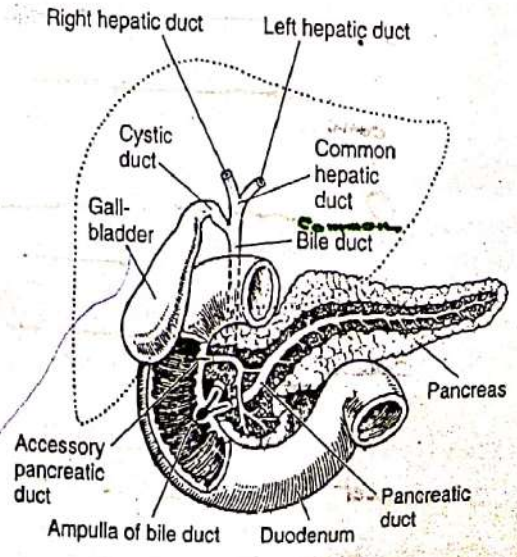
## LIVER

It develops from **endoderm**. (Weight 1.5 kg, both exocrine and endocrine). In human it is **found in right side** of abdominal cavity, below the diaphragm.

The liver is the largest gland of body.

It is **made** up of **left** and **right lobe.** Left lobe is smaller than right lobe. Right lobe forms 5/6 of the liver and left lobe forms 1/6 of liver.

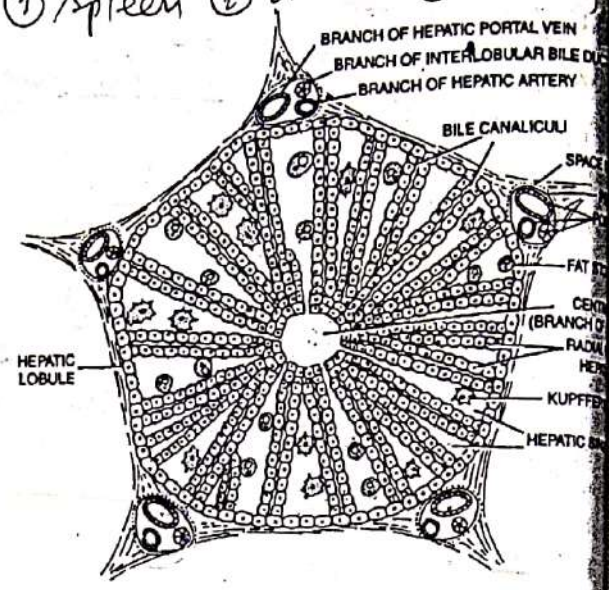
Right and left liver lobe are separate from each other by the **falciform ligament**, (Fibrous C.T.) which is made up of fold of peritoneum.



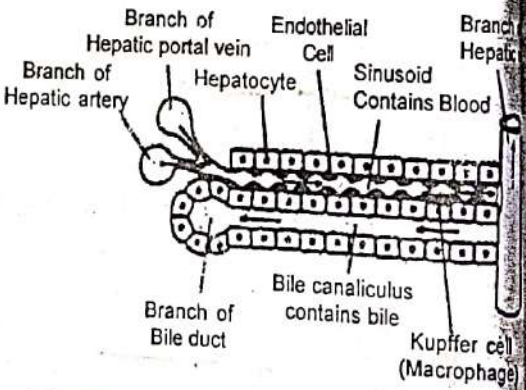
Purification of blood from dead RBC
① Spleen ② Liver.

purification of blood
① Spleen ② Liver ③ kidney

- Right and left hepatic duct drain bile from right and left hepatic lobe respectively. These ducts join to form a **common hepatic duct.**
- **Gall bladder** is situated below right lobe of liver and drained by the **cystic duct.**
- Cystic duct of gall bladder is connected to common hepatic duct to form **a common bile duct** also called **ductus choledocus.**
- The functional and structural unit of liver is **hepatic lobule.**
- Each hepatic lobules are covered by fibrous connective tissue called as **Glisson's capsule.**
- Each lobule is consists of radial rows of hepatic cells (=hepatocytes) which are called as **hepatic cord.** Each row is one or two cell wide and two cell thick.
- **Sinusoids** are lined by the **endothelial cells** mostly but a few fixed macrophages cells are also present. These are called as **Kupffer's cells.** (Phagocytic cells)
- The **bile canaliculi** run in between the two layers of cells in each cord. Hepatocytes (hepatic cells) pour bile into the canaliculi. Canaliculi open into branch of hepatic duct which is situated at the angular part of lobule in the **Glisson's capsule.**




**A part of transverse section of mammalian liver**




**Portal triad**

- All branches of hepatic duct of right and left lobe are combined to form right and left hepatic duct which come out from the liver and forms a common hepatic duct.
- Hepatic artery and hepatic portal vein enter into liver and divide to form many branches. These branches also found at the angular part. Its fine branches open into hepatic sinusoids.
- Branch of hepatic portal vein, branch of hepatic artery and branch of hepatic duct are collectively called **Portal triad.**
- All hepatic sinusoids open into central vein or intralobular vein through fine aperture. All central vein connect to form **hepatic vein** which comes out from liver and opens into inferior vena cava.

**FUNCTIONS OF LIVER :-** (Liver is known as biological and chemical factory of the body).

Most of the biochemical functions of the body are done by the liver.

**Secretion and synthesis of bile** - This is the main function of liver. **Bile is yellowish-green,** alkaline fluid. In bile juice, bile salts, **sodium bicarbonate, glycocholate, taurocholate, bile pigments, cholesterol, Lecithin** etc. are present.

**Carbohydrate Metabolism**- The main centre of carbohydrate metabolism is liver.

Following steps are related with carbohydrate metabolism-

- **Glycogenesis-** The conversion and storage of extra amount of glucose into glycogen from the digested food is called glycogenesis. The main stored food in the liver is glycogen.
- **Glycogenolysis-** The conversion of glycogen into glucose again when glucose level in blood falls down is called glycogenolysis.
- **Gluconeogenesis-** At the time of need, liver converts non-carbohydrate compounds (e.g Amino acids, fatty acids) into glucose. This conversion is called gluconeogenesis. This is the neo-formative process of glucose.
- **Glyconeogenesis :** Synthesis of glycogen from lactic acid (which comes from muscles) is called glyconeogenesis.

3. **Storage of fats-** Liver stores fats in a small amount. Hepatic cells play an important role in fat metabolism. The storage of fat increases in the liver of alcohol addict persons (Fatty liver). This stored fat decreases the activity of liver. The damage of liver due to alcohol intake is called alcoholic liver cirrhosis.
4. **Deamination and Urea formation-** Deamination of amino acids is mainly done by liver (Amino acid → $NH_3$) Liver converts ammonia (more toxic) into urea (less toxic) through ornithine cycle .
5. **Purification of blood-** Kupffer cells of liver and splenocytes of spleen are the phagocytic cells, helps in phagocytosis of dead blood cells and bacteria from the blood.
6. **Synthesis of plasma proteins-** Many types of proteins are present in blood plasma. All the blood proteins except Gamma-globulins are synthesized in the liver. Chemically antibodies are gamma globulins formed by lymphocytes. prothrombin and fibrinogen proteins are also formed in hepatic cells. These help in blood clotting. Factors I, II, V, VII , IX and X are formed in liver, which are responsible for blood clotting.
7. **Synthesis of heparin-** Heparin is a natural anticoagulant (mucopolysaccharide). Some heparin is also formed by basophils (granulated WBC) and mast cells.
8. **Synthesis of Vitamin-A-** The liver changes β-carotene into vitamin -A. β- carotene is a photosynthetic pigment which is obtain from yellow part of fruits. It is abundantly found in carrot.
9. Liver stores vitamins A,D,E,K,$B_{12}$
10. **Storage of minerals-** Liver storZes iron, copper, zinc, cobalt, molybdenum etc. Liver is a good source of iron.
11. **Detoxification-** The conversion of toxic substances into non-toxic substance is done by liver. The toxic substances are formed by metabolic activities of the body. e.g. Prussic acid is converted into Potassium sulfocynide (it is a non-toxic salt) by the liver.
12. **Haemopoiesis-** The formation of blood cells is called haemopoesis. In embryonic stage R.B.C and WBC are formed by liver
13. **Yolk synthesis (=Vitellogenesis)** Most of the yolk is synthesised in liver.

## BILE JUICE

In the duodenum bile-juice is released. The parenchyma cells of the liver produces bile-juice and it is s the Gall- bladder. Bile-juice does not contain any type of digestive enzyme, it is not called a true digesti

**Composition of bile.** Organic constituents are ($H_2O$ 98%), bile sault , **bile pigment, cholesterol,** L **inorganic constituents $Na^+$, $K^+$** etc.

| pH | 7.4 to 7.6 | $H_2O$ | 98% | daily secretion is 500 ml |
|---|---|---|---|---|

Bile-pigments are the **excretory-substances of the liver.**

**Bile contains two types of salts –**

(a) **Inorganic- salts-** Bile-juice contains NaCl, $Na_2CO_3$, $NaHCO_3$ etc in it. Inorganic salts neutralize the ac the food and make the medium basic. It is necessary for the medium to become basic because the panc juices enzymes can act only in basic -medium.

(b) **Organic salts-** Organic salts like Na-glycocholate and Na-taurocolate are found in bile juice. The main fu of these salts is the emulsification of fats because pancreatic **lipase** can act only on emulsified fats.

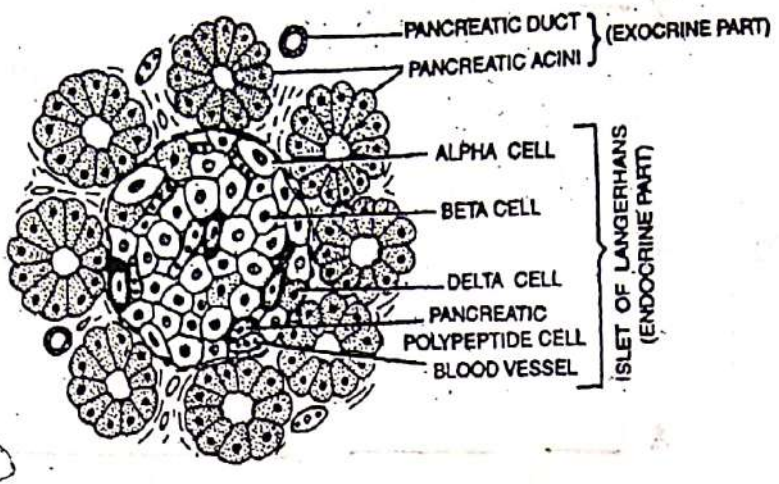
Bile salts also help in the absorption of fats and fat-soluble vitamins (A,D,E,K) bile salts combine with cholestrol, phospholipid (lecithin) and these vitamins to form compounds called **micelles**. which are abso rapidly. In the form of micelles cholestrol and phospholipid (lecithin) remain soluble.

## FUNCTION OF BILE JUICE

- **Neutralization of HCl.** Its sodium neutralizes HCl of chyme (semifluid food found in the stomach).
- **Emulsification. Sodium glycocholate** and **sodium taurocholate** are bile salts which break the larg droplets into the smaller ones.
- **Absorption of fat and fat-soluble vitamins.** Its salts help in the absorption of fat (fatty acids and glyc and fat-soluble vitamin (A, D, E and K).
- **Excretion.** Bile pigments (billirubin and biliverdin) are excretory products.
- **Prevention of decomposition.** Bile is alkaline hence it prevents the decomposition of food preventing the growth of bacteria on it.
- **Stimulation of peristalsis.** Bile increases peristalsis of the intestine.
- **Activation of lipase.** Bile contains no enzyme but activates the enzyme lipase.
- Bile-pigments, cholesterol and lecithin are the excretory substances found in bile-juice.
- **Gall stone-** Sometimes the passage inside the bile-duct gets blocked or becomes narrow, so the cholest gets deposited or precipitated in the gall-bladder. This is termed as the gall stone **(cholelithiasis)**.
- **Obstructive jaundice -** If the passage of bile is blocked then the amount of bilirubin increases in the blood. the yellowish colouration of body like skin, cornea and nails appear yellow. Urine also becomes yellow.

# PANCREAS

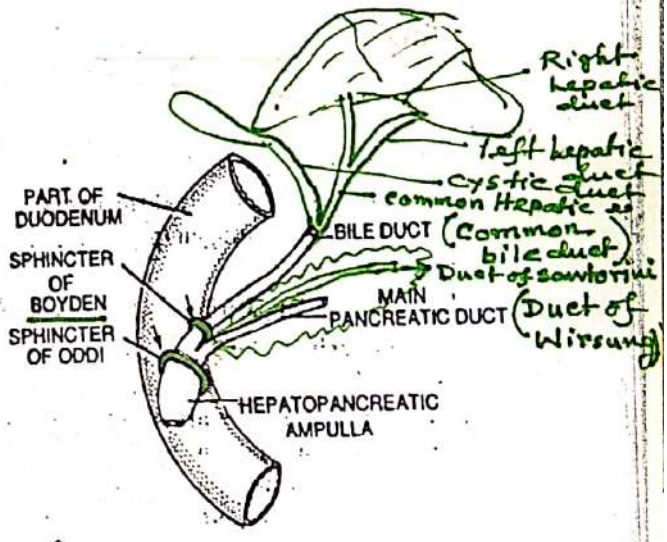
It develop from **endoderm**, which is soft, lobulated and elongated organ situated between the limbs of the U-shaped duodenum. Pancreas is exocrine as well as endocrine (Heterocrine). **Its 99% part is exocrine while 1% part is endocrine .**




Section of pancreas

**It is made up of numerous acini.** Acini is a group of secretory cells surrounding a cavity. Each acini is lined by pyramidal shaped cells. These acinar cells secrete the enzyme of pancreatic juice.

Each acini opens into pancreatic ductule. Many pancreatic ductule combine to form **main pancreatic duct (duct of Wirsung)**. The main pancreatic duct is join with the bile duct to form the **hepatopancreatic ampulla** which opens into duodenum. The accessory pancreatic duct **(duct of Santorini)** opens into duodenum with separate openings located above the opening of main pancreatic duct.




The group of endocrine cells (α, β, δ, and pp cells) found in between group of acini is called as **islets of Langerhan's**. These islets secrete glucagon, insulin, somatostatin and pancretic polypetide hormone respectively.

In humans both bile duct and pancreatic duct combine to form common duct called as **Hepato-Pancreatic duct**. The terminal end of common duct is swollen and is called as **Ampulla of Vater** or hepato pancreatic ampulla. **Ampulla of Vater** opens into middle part of Duodenum and is controlled by **sphincter of Oddi** while bile duct is controlled by **sphincter of Boyden** an alkaline. Exocrine part produces pancreatic juice while endocrine part produces glucagon, insulin, somatostatin and pancreatic polypeptide hormone.

## PANCREATIC JUICE

Pancreatic secretion of enzymes is stimulated by **CCK** and **ACh** while bicarbonate is stimulated by **secretin**.

The pancreatic-juice is secreted by the exocrine cells of the pancreas.

Pancreatic juice is highly odoriferous, colourless basic fluid which contains enzymes and salts.

**Composition of Pancreatic Juice-**

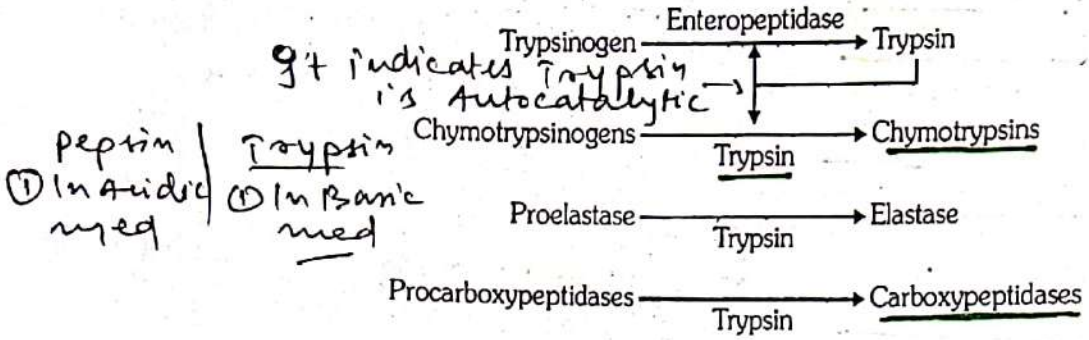
Daily secretion in human = 1 - 1.5 litre/day

Water = 98%, Salts and enzymes = 2% pH = 7.5-8.3

The action of enzymes present in the pancreatic juice is as follows-

(i) **Pancreatic α - Amylase(= Amylopsin)** dissociates starch into maltose. Majority of starch breaks in duodenum.

(ii) **Pancreatic proteases :**




* Trypsin and chymotrypsin are **endopeptidase** type of enzymes. They dissociate proteins into peptones proteoses. Majority of proteins are broken into the stomach and the remaining are broken into the duod

✓ Proteins $\xrightarrow[\text{Chymotrypsin}]{\text{Trypsin and}}$ Large peptides

Large peptides $\xrightarrow{\text{Carboxypeptidase}}$ Small peptides + amino acids

(iii) **Fat digesting enzyme** - In pancreatic-juices various fat digesting enzymes are found which are col called **steapsin**.

(i) **Pancreatic lipase**- It converts triglyceride into di and monoglyceride.
(ii) **Cholesterol esterase**- It digests **cholesterol esters**.
(iii) **Phospholipase**- These digest phospholipids.

**Nucleases (= DNase and RNase)** - Digestion of DNA and RNA respectively into nucleotides

## PHYSIOLOGY OF DIGESTION

Digestion is divided in two ways-mechanical digestion and chemical digestion. Mechanical digestion take in mouth and small intestine.

### DIGESTION IN ORAL CAVITY

**Mechanical digestion**

- In mouth teeth, tongue and lips have Important role in mechanical digestion through the process of che **mastication.**

**Chemical digestion**

**Ptyalin :-**

$\text{Starch} \xrightarrow{\text{Ptyalin}} \text{Maltose} + \alpha\text{-Dextrin}$ + Iso Maltose

- Ptyalin is found in human saliva, because human food is mainly made up of starch. Ptyalin digest only ripe cooked starch. It does not digest the raw starch, **30% starch in buccal cavity is digested by ptyalin.**
- Ptyalin is absent in saliva of rabbit and carnivorous animal, because food of rabbit is mainly made up of cell
- Bolus is pushed inward through the pharynx into the oesophagus this process is called **swallowing or deglu** it is coordinated activity of tongue, soft palate, pharynx and oesophagus.
- The tongue blocks the mouth, part of soft palate uvula close off the internal nasal opening and larynx ris that epiglottis closes off the trachea food move downward into the oesophagus A travelling wave of constri called peristalsis pushes the bolus (food) downward.

Peristalsis is progression of coordinated contraction of involuntary circular muscles, which is preceded simultaneous contraction of the longitudinal muscle and relaxation of the circular muscle in the lining of

- When a peristaltic wave reaches at the end of the oesophagus. (Digestion or digestive enzymes are absent in oesop
- The cardiac sphincter(= Gastroesophageal sphincter) opens allowing the passage of bolus food to the stomach Gastroesophageal sphincter normally remains closed and does not allow food contents of the stomach to move

## DIGESTION OF FOOD IN STOMACH :

When the food enters into stomach G-cells secrete gastrin hormones which stimulate the secretion of gastric juice by gastric glands.

Secretion of gastric juice is controlled by nerve, hormones and chemical substances.

Some drinking substances also stimulates the secretion of gastric juice such a soup, alcohol, caffeine, histamine. These drinking substance and gastric juice stimulate the desire of appetite. So these substances are called appetiser juice.

**Digestion by Rennin (Chymosin)**

Rennin is active in the **childhood stage** of mammals only. It converts milk into curd like substance (clot the milk) and then digests it. In adult stages, it is inactive.

**Rennin**, acts on milk protein **casein**. Casein is a soluble protein.

In presence of Rennin, casein gets converted into insoluble **Ca-paracaseinate**. This process is termed as **Curdling of milk**. After becoming insoluble, milk can remain in the stomach for a longer time. **Rennin is absent in adult human** (curdling of milk is done by HCl, pepsin and chymotrypsin in human).

**Digestion by pepsin**

Inactive pepsinogen on getting proper pH converts into active pepsin.

**Protease** :- The enzyme which breakes the peptide bond. These protease are of two types.

- **Exopeptidase :-** The peptidase enzyme which breaks the outer and marginal bond of polypeptide called exopeptidase. In this process amino acid and polypeptides are formed.
- **Endopeptidase :-** The peptidase enzyme which breaks the inner peptide bond of large polypeptide and forms the small polypeptides such as pepton, proteoses and peptides.

Pepsin is an **endopeptidase**. It breaks proteins into smaller molecules.

$$\text{Proteins} \xrightarrow{\text{Pepsin}} \text{Peptones} + \text{Proteoses} + \text{Peptides}$$

In stomach, endopeptidases are found so only digestion of proteins can take place properly in the stomach.

**Digestion by Gastric Lipase-**

It converts fats into fatty acids and monoglyceride. It is secreted in a less amount so less digestion of fats takes place here.

This lipase acts on emulsified fat and convert it into fatty acid and glycerol. 1% emulsified fat is present in the food.

**Peristalsis** continues during the process of digestion so the gastric -juice mixes properly with the food. Due to peristalsis the food is converted into a paste. This form of food which is thick, acidic and semidigested in the stomach is called **chyme**.

After short intervals, the pyloric sphincter keeps on opening and closing so the chyme is fed into the intestine in installments.

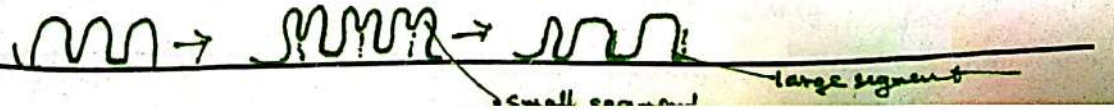
## DIGESTION OF FOOD IN SMALL INTESTINE-

In small intestine mechanical and chemical digestion occurs.

**Mechanical digestion :**

This process of digestion mainly occurs by the help of **segmentation.** It is a mixing of kind with digestive juice and bring food particle in to contact of mucosa.

- It starts with contraction of circular muscle this action constrict the intestine in small segment and further each segment constrict from middle and divide each constricted segment again, finally first contracted fibre relax and each small segment unite with adjoining small segment, so large segment form again.



Q- which substance can't be digested in human body?
Ans: Glucose and other end product

Small Intestine

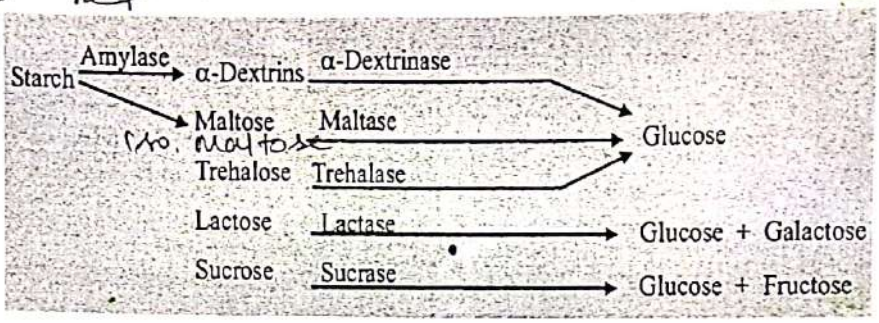
**Chemical digestion :**

When food leaves the stomach through its pyloric end and enters the duodenum it is called chyme (a
The intestinal mucosal epithelium has **goblet cells** which secrete **mucus.**

**The secretions of the brush border cells of the mucosa alongwith the secretions of the gob constitute the intestinal juice or succus entericus.** This juice contains a variety of enzymes like nase aminopeptidase disaccharidases (e.g., maltase), dipeptidases, lipases, nucleosidases, etc. Th alongwith the bicarbonates from the pancreas protects the intestinal mucosa from acid as well as p alkaline medium (pH 7.8) for enzymatic activities. Sub-mucosal glands (Brunner's glands) also help in

**Succus-entericus mainly contains the following enzymes-**

**Glycosidases**




This succus entericus mainly contains water (99%) and digestive enzymes (<1%).

**Peptidase** - This is a type of **exopeptidase.** It converts oligopeptides into amino acids.

Large Peptides $\xrightarrow{\text{Amino peptidase}}$ Small peptides + Amino acid

After emulsification

**Intestinal Lipase-** This fat-digesting enzyme converts fats into **monoglyceride and fatty-acid.**

**Nucleotidase and Nucleosidase -** These act in the following way:-

Nucleotides $\xrightarrow{\text{Nucleotidase}}$ Nucleosides + Phosphate

Nucleosides $\xrightarrow{\text{Nucleosidase}}$ Pentose + Nitrogen bases

## DIGESTION IN LARGE INTESTINE :-

No significant digestive activity occurs in the large intestine. The functions of large intestine are:

(i) absorption of some water, minerals and certain drugs;

(ii) secretion of mucus which helps in adhering the waste (undigested) particles together and lubricati for an easy passage.

(iii) *Escherichia coli* (bacterium) lives in the colon which feeds on undigested matter. This bacterium, i produces Vitamin $B_{12}$, $B_1$, $B_2$ and K that are absorbed by the wall of the colon.

The undigested, unabsorbed substances called faeces enters into the caecum of the large intestine thro ileo-caecal valve, which prevents the back flow of the faecal matter. It is temporarily stored in the rectu defaecation.

Same for intestinal lipase

Triglyceride $\xrightarrow{\text{Pan-Lipase}}$ Diglyceride + F-A

Diglyceride $\xrightarrow{n}$ Monoglyceride + F-A

Mono $\xrightarrow{n}$ glycerol + F-A

## Control and co-ordination of GIT

The activities of the gastro-intestinal tract are under neural and hormonal control for proper coordination of different parts. The sight, smell and/or the presence of food in the oral cavity can stimulate the secretion of saliva. Gastric and intestinal secretions are also, similarly, stimulated by neural signals. The muscular activities of different parts of the alimentary canal can also be moderated by neural mechanisms, both local and through CNS. Hormonal control of the secretion of digestive juices is carried out by the local hormones produced by the gastric and intestinal mucosa.

### An overview of the action of major digestive enzymes

| Enzyme | Site of Action | Substrate | Products of Action |
|---|---|---|---|
| **Salivary Juice (Salivary Gland)** | | | |
| Salivary amylase or Ptyalin | Buccal cavity | Starch | Disaccharides (few) |
| **Gastric Juice (Stomach)** | | | |
| Pepsin (endopeptidase) | Stomach | Proteins | Large peptides |
| **Pancreatic Juice (Pancreas)** | | | |
| Pancreatic α-amylase | Small intestine | Starch | Disaccharides |
| Trypsin (Endopeptidase) | Small intestine | Proteins | Large peptides |
| Chymotrypsin (Endopeptidase) | Small intestine | Proteins | Large peptides |
| Elastase | Small intestine | Elastin | Oligopeptides |
| Carboxypeptidases (Exopeptidase) | Small intestine | Large peptides | Amino-acid |
| Lipase | Small intestine | Triglycerides | Monoglycerides fatty acids, |
| Nucleases | Small intestine | Nucleic acids | Nucleotides |
| **Intestinal Juice (Small Intestine)** | | | |
| Enteropeptidase or enterokinase | Small intestine | Trypsinogen | Trypsin |
| Aminopeptidase (Exopeptidase) | Small intestine | Large peptides | Amino-acid |
| Peptidase (Exopeptidase) | Small intestine | Oligopeptides | Amino acids |
| Disaccharidases | Small intestine | Disaccharides | Monosaccharides |
| Nucleotidase | Small intestine | Nucleotides | Nucleosidases phosphoric acid |
| Nucleosidases | Small intestine | Nucleosides | Sugars, purines pyrimidines |
| Lipase | Small intestine | Triglycerides | Monoglycerides, glycerol fatty acids |

## Role of some major gastrointestinal hormones

| Hormone | Source of secretion | Stimulus | Target/Action |
|---|---|---|---|
| Gastrin | Pyloric stomach and duodenum (G-cells) | Vagus nerve activity; peptides and proteins in stomach. | Secretory cells muscles of stoma secretion of HCl stimulation of gas motility. |
| Cholecystokinin (CCK) (CCK-EZ) → enzymes → Panc | Duodenum (I-cells) or CCK cells | Food (fatty chyme and amino acids) in duodenum. | Gall bladder; contrac of gall bladder release) |
| Secretin | Duodenum (S cells) | Food and strong acid in stomach and intestine. | Secretion of water bicarbonate fro pancreas inhibition of gastr motility, ↑↑ It stimulate liver for t secretion of bile juice |
| Glucose dependent Insulino tropic Peptide (Gastric Inhibitory Peptide) (GIP) | Duodenum (K-cells) | Monosaccharides and fats (fatty chyme) in duodenum. | Gastric mucosa an muscles; inhibition o gastric secretion an mobility/motility (slowin food passage) |
| Duocrinin | Duodenum | acidic chyme | Stimulate brunner gland to secrete alkalin mucus. |
| Enterocrinin | Duodenum | ... | Stimulated paneth cel for synthesis an secretion of enzymati part of intestinal juice. |
| Villikinin | Duodenum | ... | It stimulates the activi of villi. |
| Vasoactive intestinal peptide (VIP) | Duodenum | ... | They inhibits the motili of stomach |

enterogasterone → motility inhibition of stomach

## 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 monosaccharides 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 gradient. However, 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**. Active transport occurs against the concentration gradient and hence requires energy. Various nutrients like **amino acids, monosaccharides like glucose, electrolytes like Na⁺** are absorbed into the blood by this mechanism.

Q. which of the following is not found in Hepatic portal system?
Ans: Fats + Glycerol (chain

**Absorption in buccal cavity :-**

No absorption of food takes place in the oral cavity. Only some chemicals/medicines and alcohol are absorbed in buccal cavity.

**Absorption in stomach :-**

In the stomach, **absorption of water, some salts, alcohol, glucose** and **few drugs like aspirin takes place.**

**Absorption in small intestine –**

**Iron** and **calcium** ion are absorbed in the duodenum. **Maximum absorption** take place in jejunum. **Vitamin-$B_{12}$** and **bile salts** are absorbed in ileum. Millions of microscopic folds or finger like projections are present in the lumen of gut which are called villi **villus is unit of absorption.**

These villi are supplied with a network of blood capillaries and lymphatic capillaries **(lacteals)** . The cells that line the surface of villi are called enterocytes and bears numerous microscopic bristle like projections are called microvilli or brush border. These further increase the surface area for the absorption of the nutrients/digested food. On the surface of the mucous epithelium mucous or **goblet cells** are present and secrete mucus that acts as a lubricant and protects the epithelial surface from damage and digestion.

**Absorption of Carbohydrate**

Monosaccharides are absorbed via the capillary blood with in the villus to finally reach into portal vein. Absorption of **glucose** molecules occurs along with **$Na^+$ by active symport (Co-transportation)** and **fructose** is absorbed by **facilitated diffusion,** because concentration of glucose is higher in lumen where as concentration of fructose is low in cells.

**Absorption of amino acid –**

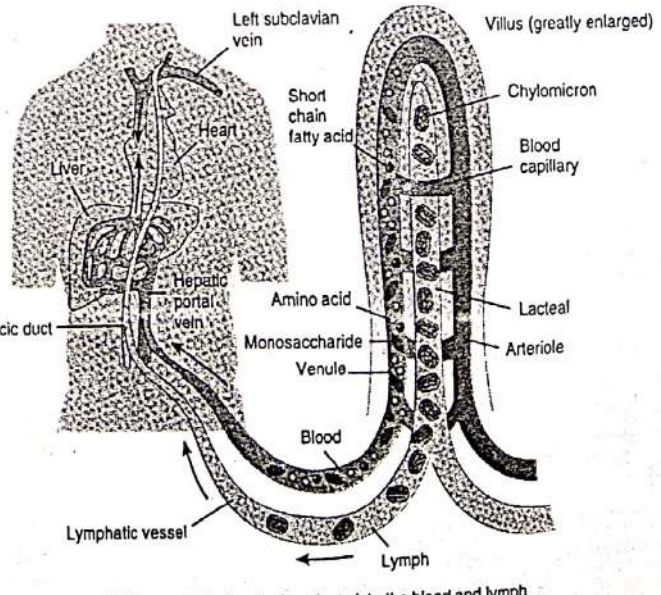
The **L-amino acids** are naturally occuring and are absorbed by **active transport** against the concentration gradient while **D-amino acid** are absorbed **passively by diffusion.**

Some amount of dipeptide and tripeptide enter the enterocytes where they are hydrolyzed to amino acids by dipeptidases and tripeptidases to get absorbed via portal veins.

**Absorption of fat –**

One molecule of triglyceride is hydrolyzed into one molecule of monoglyceride and two molecule of fatty acids by pancreatic lipase.

After hydrolysis, the bile salt, monoglyceride and the fatty acid together produce a complex called a **mixed micelle.** These are water soluble and enter in the enterocytes. Monoglyceride and fatty acid are resynthesized with in enterocyte to form a molecule of triglyceride (TG). TG combines with a small amount of protein and resultant complex is called **chylomicron** (150 µm, white).



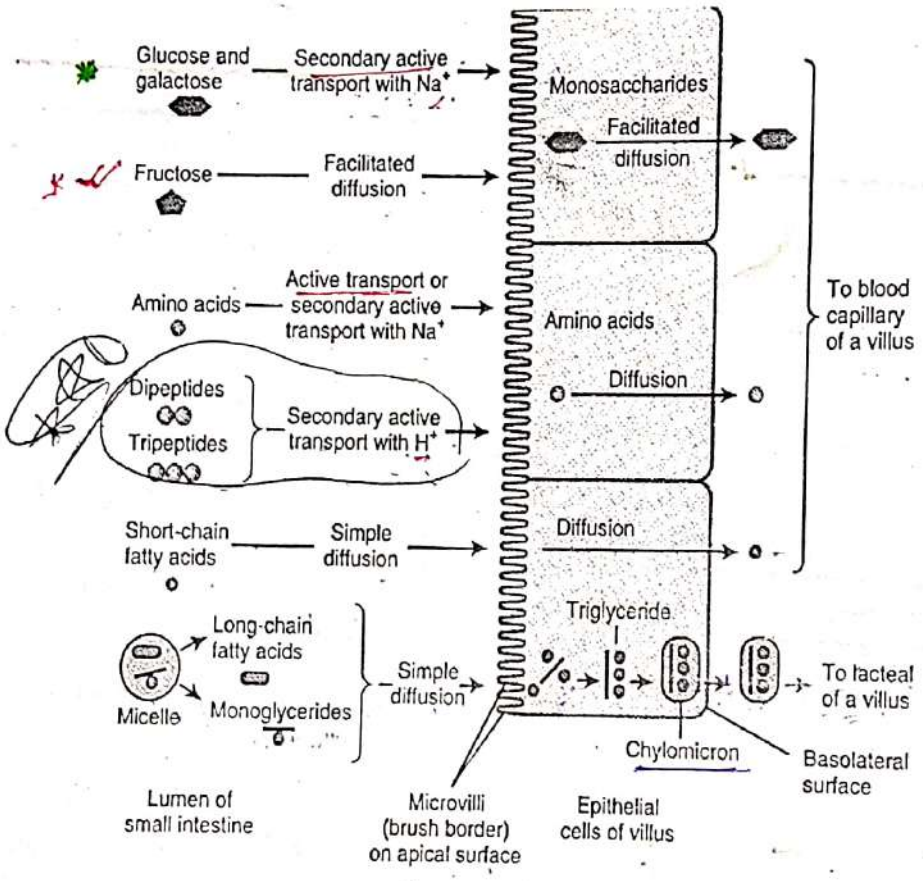

(b) Movement of absorbed nutrients into the blood and lymph

**Chylomicron enters the lacteal.**

- Fat soluble vitamins are absorbed along with dietary fat whereas water soluble vitamins are absorbed by diffusion. Vit. $B_{12}$ is absorbed with intrinsic factor by forming a complex.
- All lymph- capillaries coming out of the alimentary canal unite to form **lymph vessels**. All lymph coming from the alimentary canal open into the **left thoracic lymph duct**. This duct now opens into **subclavian vein**. Through the blood, fats reaches the heart and from here it is distributed throughout

**Absorption in colon**

- Colon absorbs water from the undigested food. **Haustra** help to increase the absorptive surface of co




(a) Mechanisms for movement of nutrients through absorptive epithelial cells of the villi

**The Summary of Absorption in Different Parts of Digestive System**

| Mouth | Stomach | Small Intestine | Large Intestin |
|---|---|---|---|
| Certain drugs coming in contact with the mucosa of mouth and lower side of the tongue are absorbed into the blood capillaries lining them. | Absorption of water, simple sugars, and alcohol etc. takes place. | Principal organ for absorption of nutrients. The digestion is completed here and the final products of digestion such as glucose, fructose, fatty acids, glycerol and amino acids are absorbed through the mucosa into the blood stream and lymph. | Absorption water, (so minerals a drugs takes plac |