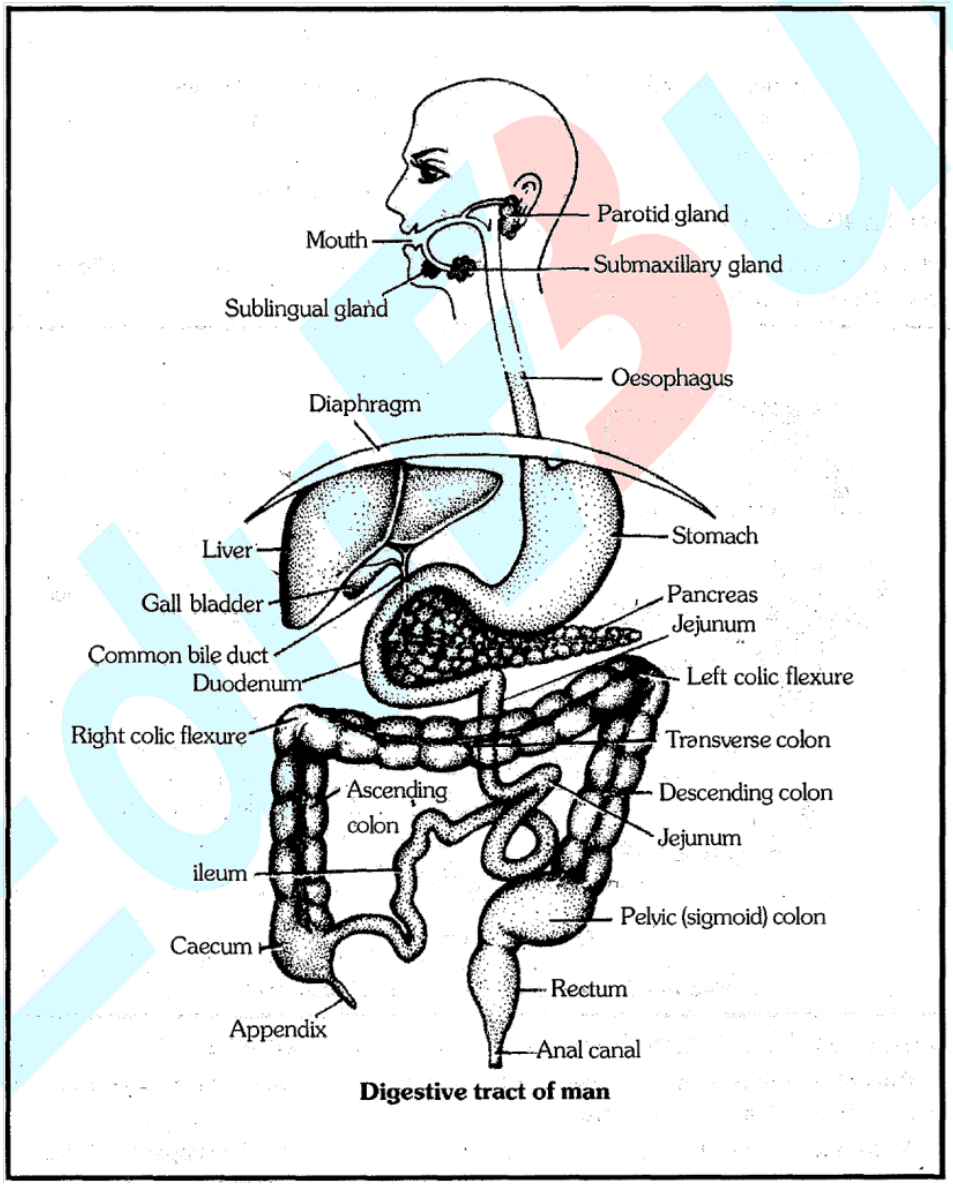
DIGESTION AND ABSORPTION

- 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.

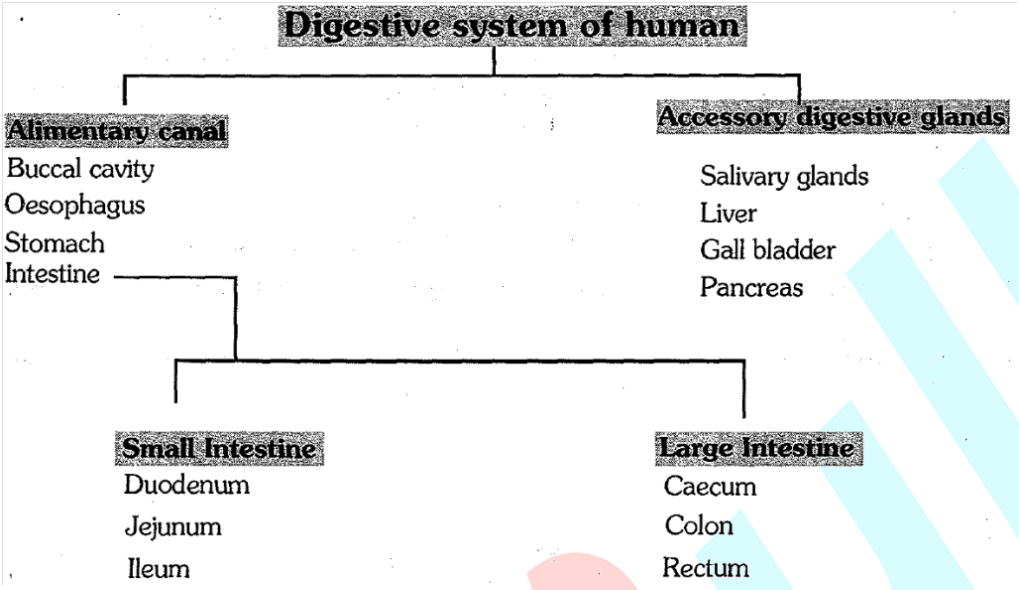
The general organisation of the human digestive system can be represented by following diagram.



Digestive tract of man

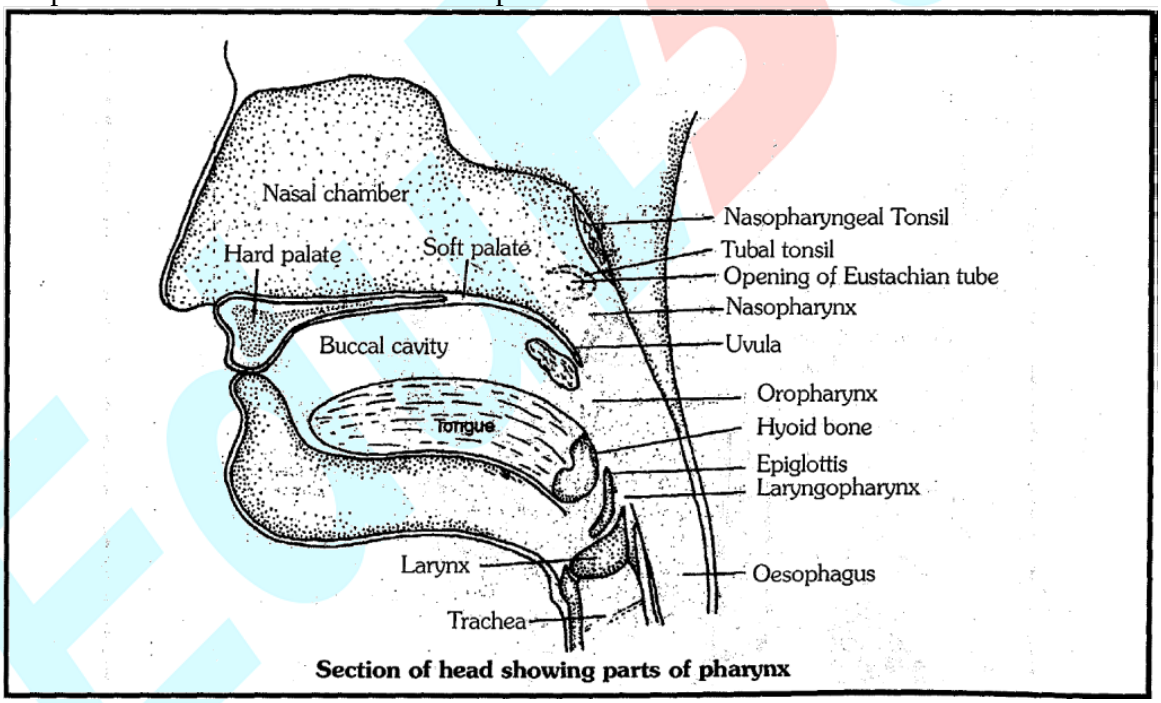
Origin

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



(1) MOUTH AND BUCCOPHARYNGEAL CAVITY -

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



Section of head showing parts of pharynx

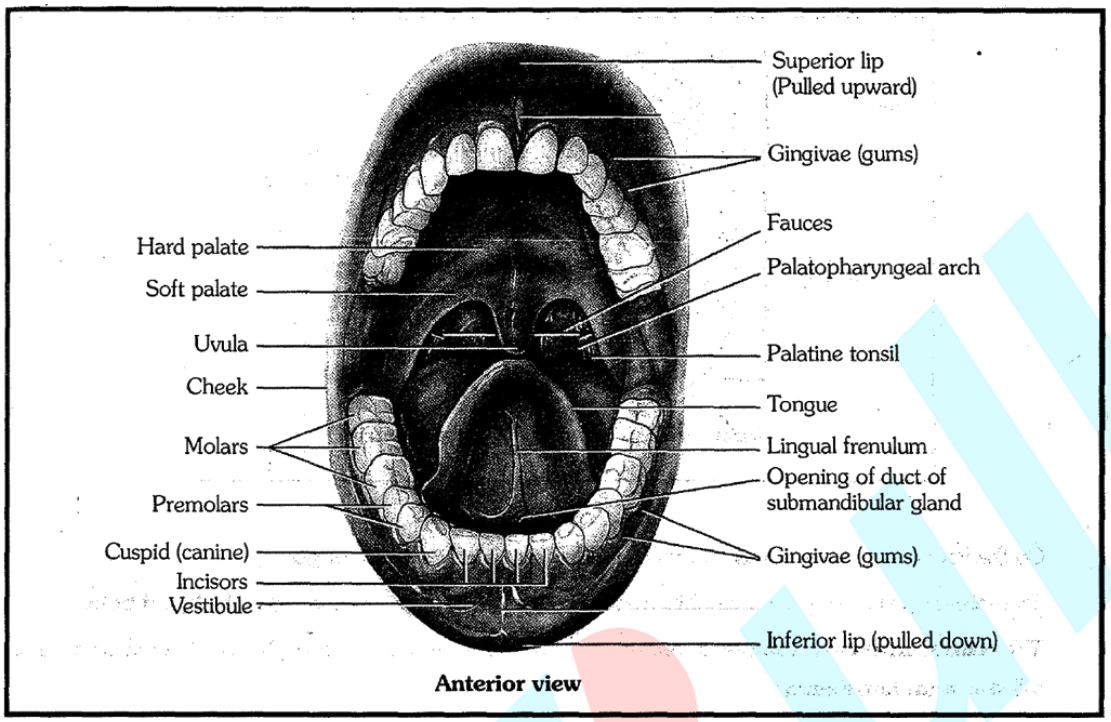
Mouth opens into buccopharyngeal cavity, this cavity is divided into two parts.

(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

Palate is differentiated into two parts :



Anterior view

(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.

(ii) Soft Palate -

It is the posterior part palate. It is made up of 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. 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 cannot move inside nasal chamber.

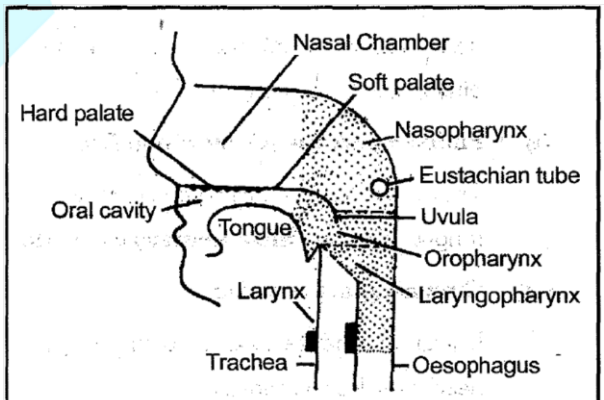
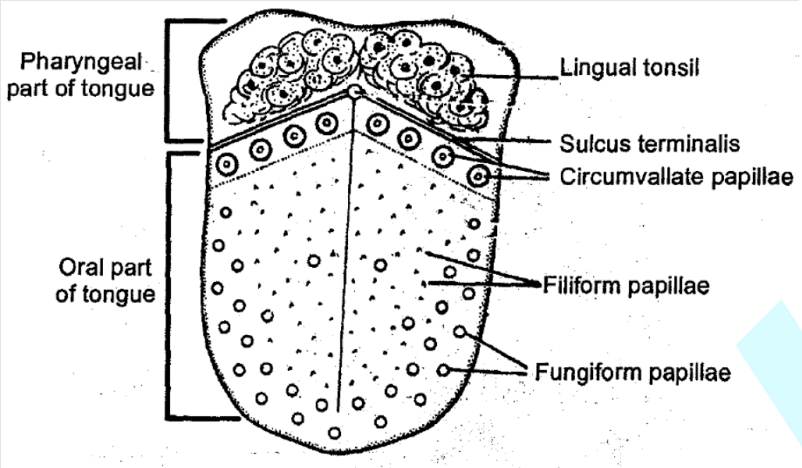


Diagram showing parts of pharynx

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

TONGUE.



Upper surface of human tongue (Dorsal)

On the floor of oral cavity a muscular 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 oral cavity through a very flexible membrane called as frenulum linguae.

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

PAPILLAE

Three types of functional papillae are found in this part in which gustatory or taste receptors are 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 mostly present at the anterior part of tongue. It is attached to tongue with the help of small pedicle. It provides pink colour to the tongue.

(ii) Filiform 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 found c near the sulcus terminalis.

Function of Tongue : Reception of taste. Taste buds are modification of epithelium.

TEETH

Teeth are ectomesodermal in origin.

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

STRUCTURE OF TOOTH

Tooth is differentiated in three parts.

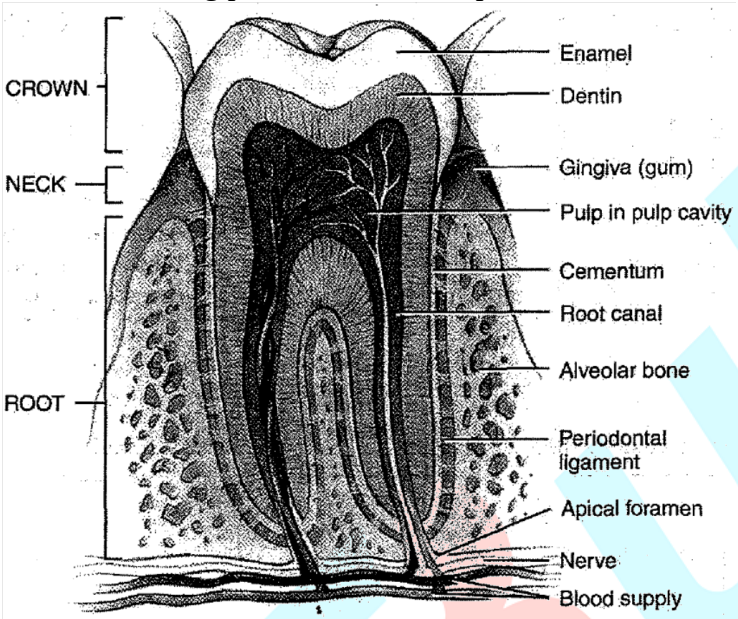
Crown- It is the outer part of the tooth, exposed outside gums.

Neck- It is the internal part of the tooth which is embeded inside the gums.

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. Inorganic salt (app. 96%) are mainly found in the form of **phosphate of Ca^{+2}**, 3% of water is found in the enamel. Along with it amelogenin and enamelin protein (1%) are also found in enamel. Ossein is a protein of bones. Remaining part of teeth develop from mesoderm of embryo.



section of a mandibular (lower) molar

Dentine is the **main part of tooth.**

Dentine surrounds a cavity called pulp-cavity. 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.

Four types of teeth found in mammals are -

Incisor- These are long, chisel like teeth for gnawing the food.

Canines- These are sharp pointed teeth meant for tearing and shearing the food. Canines are absent in herbivorous animals e.g. Rabbits do not have canines. In 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 shape.

Molars (Cheek teeth)- These also meant for chewing and crushing of food. They are rectangular in shape. 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 during childhood are called milk teeth/temporary teeth/lacteal teeth/deciduous teeth/primary teeth. Due to the activity of osteoclast cells, these milk teeth are shed, then permanent teeth appear.

HUMAN DENTITION :- Arrangement of teeth on jaws is dentition. Human dentition has following features.

(1) **(A) Monophyodont :-** The teeth which appear only once in life. eg. Premolars and last molars of human.

(B) Diphyodont :- The teeth which appear twice in life. eg. Incisors, Canines, 1^{st} and 2^{nd} molars.

(2) **Thecodont :-** The teeth which are present in bony socket of Jaw. eg. Human and Crocodile.

(3) **Heterodont :-** When the teeth are of different type in mammals on the basis of structure and function.

Dental formula :-

Child =

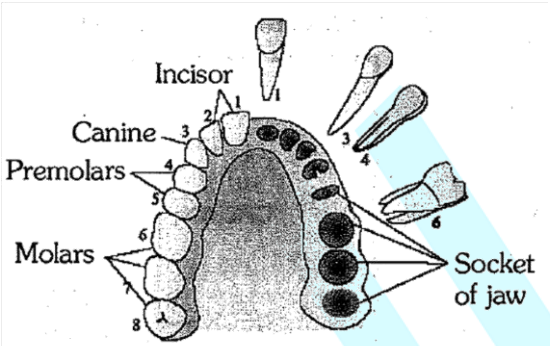
$$1\frac{2}{2}C\frac{1}{1}PM\frac{0}{0}M\frac{2}{2}\times 2=\frac{10}{10}=20$$

17 Yr. old =

$$1\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{2}{2}=\frac{7}{7}\times 2=28$$

Adult =

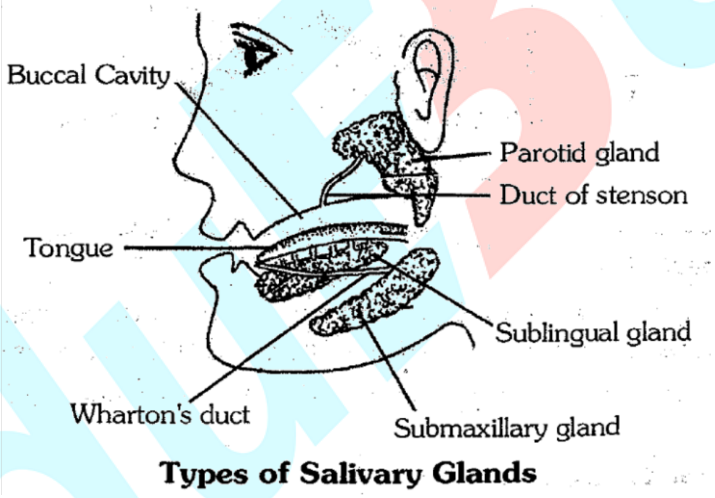
$$1\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{3}{3}=\frac{8}{8}\times 2=\frac{16}{16}=32$$



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

SALIVARY GLANDS

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



Types of Salivary Glands

	Parotid glands	Submandibular submaxillary glands	Sublingual glands
Location	Near ear (cheeks)	At the junction of upper and lower jaw	Below tongue
Size	Largest	Medium sized	Smallest
Ducts	Stenson's ducts	Wharton's ducts (Longest salivary duct)	Ducts of Rivinus (Shortest salivary duct)
Opening of Ducts	In vestibule of upper jaw	Behind lower incisors	In buccopharyngeal cavity on ventral side of tongue
Saliva	25%	70% (Maximum)	5% (Minimum)
Nerve	IX	VII	VII

Saliva :- Secretion of salivary glands.

Daily secretion = 1500 mi. (approx)

pH = 6.8
Composition = H_2O = 99.5%
Salivary amylase (Ptyalin) → Mainly by parotids.
→ Lysozyme, mucus and thiocyanates.
→ Few ions like Na^+, K^+, Cl^-, HCO_3^-
→ IgA antibody
→ Small amount of urea and uric acid.

HISTOLOGY OF ALIMENTARY CANAL

Unilayered Epithelium in Stomach, duodenum, jejunum, ileum

Mucosa: Epithelium	Multilayered Epithelium	Simple columnar glandular epithelium form Gastric Glands	Simple columnar glandular brush border Epithelium form Blunt-Villi	BBGCE form Long-Pointed Villi
Mucosa: Lamina Propria Areolar Connective tissue			Crypts of Lieberkuhn	Paneth cells; Peyer's patches
Mucosa: Muscularis mucosa	Circular Longitudinal	Circular Longitudinal	Circular Longitudinal	Circular Longitudinal
Submucosa of Areolar CT rich in blood vessels, Lymph vessels and nerve fibres			Brunner's Glands	
	Branches of Sympathetic and parasympathetic nerve fibres (Meissner's nerve plexus)			
Muscularis Layers: Circular	Circular	Oblique / Circular	Circular	Circular
Muscularis Layers: Nerve Fibres	Branches of Sympathetic and parasympathetic nerve fibres (Auerbach's nerve plexus)			
Muscularis Layers: Longitudinal	Longitudinal	Longitudinal	Longitudinal	Longitudinal
Serosa-Made up of simple squamous epithelium or mesothelium	Areolar CT and WFCT present, called tunica adventitia	SSE + Fats + Lymph Tissues = Ommentum	Serosa	Serosa
	Oesophagus	Stomach	Duodenum	Jejunum and Ileum

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 c.t. and simple squamous epithelium (= mesothelium). Some part of gut is lined with tunica adventitia which is made up of WFCT and Areolar C.T.

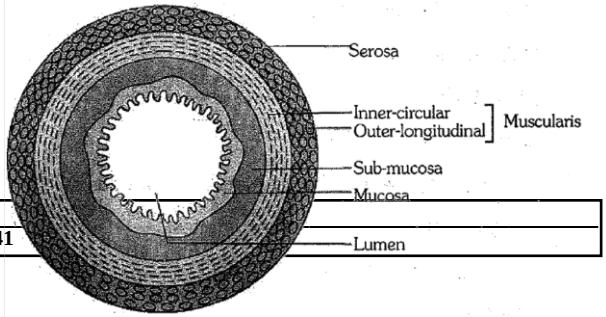
(2) Muscle layer :

(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 thinnest layer in rectum (minimum peristalsis).
(iii) Stomach contains an additional obligue muscle layer just interior to circular muscle.

(3) Submucosa : It is composed of areolar connective tissue layer with blood vessels. Lymph vessels and nerves.

(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.

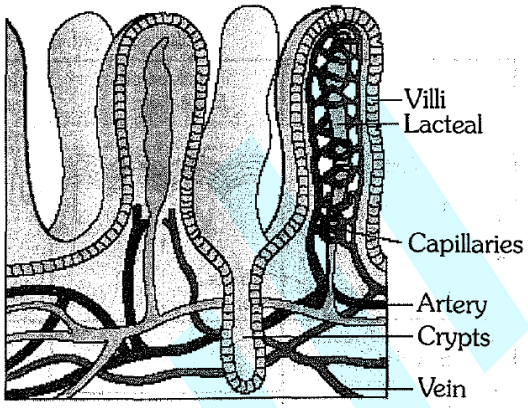
- It is made up of areolar connective tissue.

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

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, whereas folds of stomach are finger shaped and develop as gland called gastric gland.

Folds of small intestine are conical shaped called villi. 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 (brush bordered epithelium)



A section of small intestinal mucosa showing villi

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

Maximum villi are found in Jejunum.

Brunner's 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 HCI.

Paneth cells :-

These cells are found in Crypts of Lieberkuhn of mucosal layer of small intestine.
They are unicellular glands.
These cells secrete defensin and lysozyme hence it provides immunity.

Peyer's patches:-

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

Enteric nervous system

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

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

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.

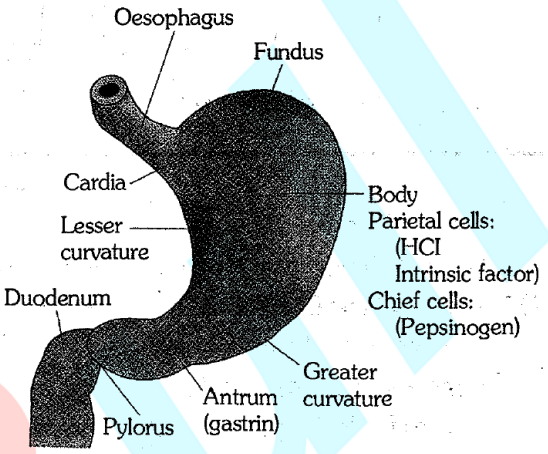
OESOPHAGUS

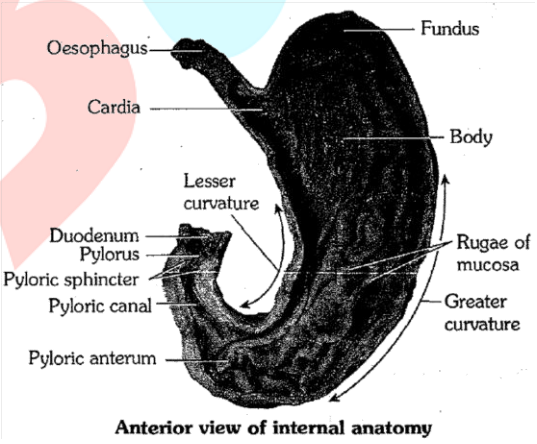
- Oesophagus is a thin. long simple uniform tube which runs downward and pierces the diaphragm and finally opens into stomach.
- It lacks serosa, but tunica adventitia is present.

- Two apertures found in oropharynx are-
- Ventral aperture is called glottis which is related to the larynx, which is guarded by epiglottis (elastic cartilagenous flap).
- The Dorsal aperture is called gullet which opens into the oesophagus.

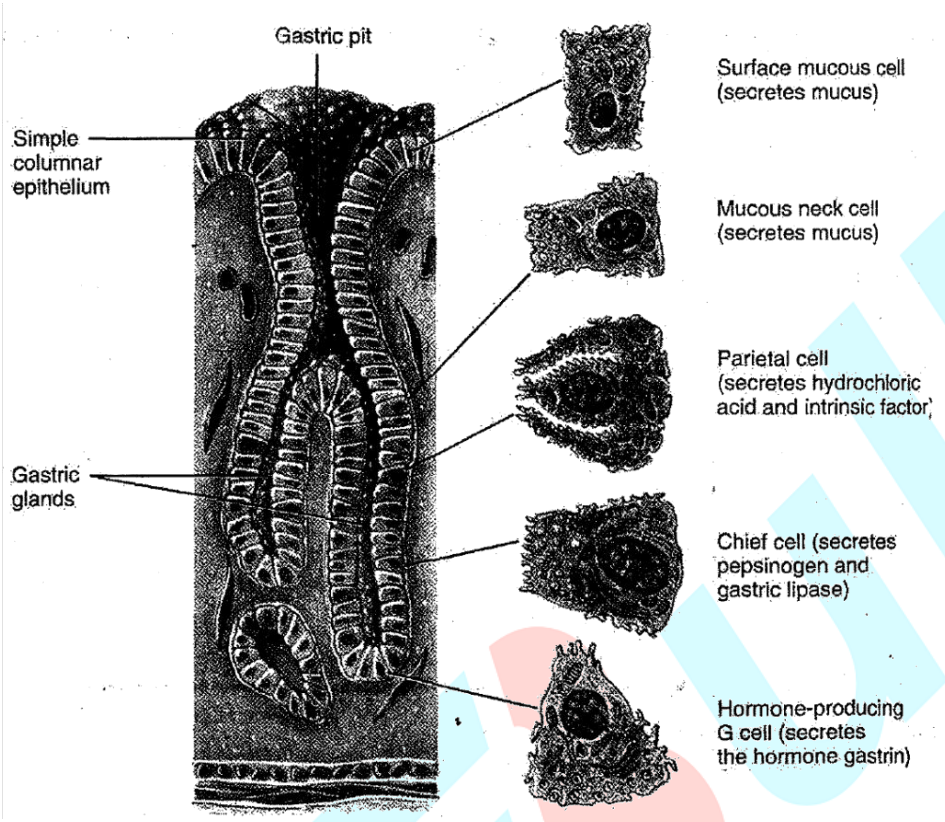
STOMACH

- 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 is called Omentum. Greater curvature attached with more deposition of lymph tissues and fat.
- Left curved surface of stomach is called greater omentum. Right curved surface of stomach is called lesser curvature.
  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 add. HCl provides the acidic pH (pH 1.8) optimal for pepsin.





Anterior view of internal anatomy



Sectional view of gastric gland

Gastric Glands :- These are numerous microscopic, simple branched 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.

(1) 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 lipase.

Gastric lipase contributes little to digestion of fat.

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.

(2) Oxyntic cells (=Parietal cells) are large and are most numerous on the side walls of the gastric glands. They secrete hydrochloric acid and Castle's intrinsic factor.

Functions of HCI -

1. The main function of HCI (activator) is to convert inactive enzymes (zymogens) into active enzymes. Pepsinogen and Prorennin are inactive enzymes.

   Pepsinogen $\xrightarrow{HCl}$ Pepsin.

   Prorennin $\xrightarrow{HCl}$ Renin.

2. It destroys all the bacteria present in the food.
3. HCI 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.

(3) Mucous neck cells are present through out the surface epithelium and secrete mucus.

(4) Enteroendocriile 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.

- 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 and stimulates the smooth muscles. Histamine dialates the walls of blood vessels. Gastrin stimulates the gastric glands to release the gastric juice.

Composition of Gastric juice :

Water = 99.5%
HCI = 0.2 - 0.3%
pH = 1.5 to 2.5 (very acidic)
Rest is mucus, water and gastric enzymes (Pepsinogen, Prorennin, Gastric lipase etc.).

INTESTINE

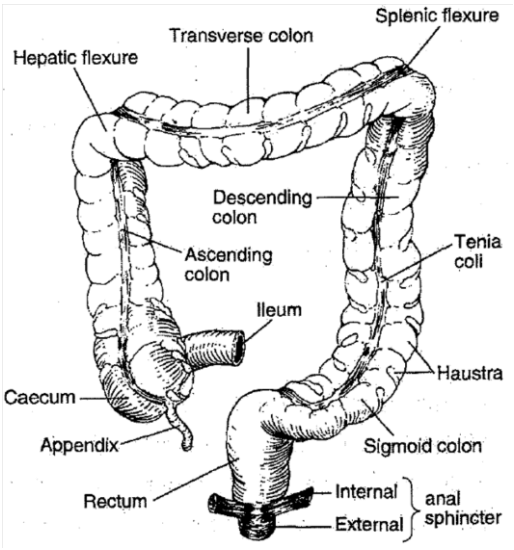
It is divided into two part
(i) Small intestine (ii) Large intestine

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 the fixed part of the small intestine.
- For the efficient absorption of digested food large surface area is required. Therefore some modifications are present here.
  (1) Greater length of the intestine.
  (2) The presence of permanent deep folds in mucosa is called plicae circularis, valvulae conniventae or valves of kerckring.
  (3) Villi
  (4) Microvilli

LARGE 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 Ileocaecal junction. The lleocaecal 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 vestigeal organ. (Caecum is wen developed in rabbit and not well developed in human).

COLON

- Colon of human has ascending, transverse and descending part.
- 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.

- A type of contraction that occurs only is the colon in the mass action contraction.

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.

GOLDEN KEY POINTS

1. Soft palate is made up of muscle, fibrous connective, tissue and mucous epithelium.

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

3. Auerbach's nerve plexus is found between longitudinal muscles and circular muscles, it start muscle contraction to initiate peristalsis.

4. Meissener's nerve plexus is found between circular muscles and submucosa but in stomach found between oblique muscle and submucosa, it regulate the secretion of epithelial mucosa.

5. Somatostatin suppresses the release of hormones from the digestive tract. Seratonin is vasocontrictor and stimulates smooth muscles. Histamine dialates the walls of blood vessels. Gastrin stimUlates the gastric glands to release the gastric juice.

6. Least perastalsis occurs in Rectum.

BEGINNER'S BOX - 1

ANATOMY OF ALIMENTARY CANAL

1. Dental formula of adult man is -

(1) $\frac{2,1,2,3}{2,1,2,3}$ (2) $\frac{2,1,2,3}{2,1,2,2}$ (3) $\frac{2,1,2,3}{2,1,2,4}$ (4) $\frac{2,1,3,2}{2,1,3,2}$

2. In Colon, constrictions of its wall form a series of small pockets called-

(1) haustra (2) crypts of lieberkuhn
(3) zymogen cells (4) taenia

3. pH of stomach in human is about-

(1) 7 (2) 3 (3) 8 (4) 11

4. Number of teeth which are monophyodont in man is-

(1) 4 (2) 22 (3) 32 (4) 12

5. The cells of the epithelial lining in the vertebrate stomach are not damaged by HCl because of-

(1) Mucus secretion covering the epithelium
(2) Neutrilizatioin of HCl by alkaline gastric juice.
(3) HCl being to dilute
(4) Epithelium being resistant to HCl

6. The structure which prevents entry of food into windpipe during swallowing in mammals is-
(1) Larynx (2) Glottis (3) Epiglottis (4) Pharynx

7. Which of the following is a common passage in swallowing food and breathing-
(1) Pharynx (2) Larynx (3) Glottis (4) Gullet

8. The hardest constituent of the tooth is-
(1) Enamel (2) Dentine (3) Bone (4) Pulp

9. Types of teeth in human-
(1) Thecodont (2) Acrodont (3) Pleurodont (4) Homodont

10. Posterior part of soft palate, hangs down in pharynx, called-
(1) Palatine (2) Tonsils (3) Velum Palati (4) Jacobson's organ

11. Nasal chambers and buccal cavity are separated by-
(1) Uvula (2) Palate (3) Palatine (4) None of these

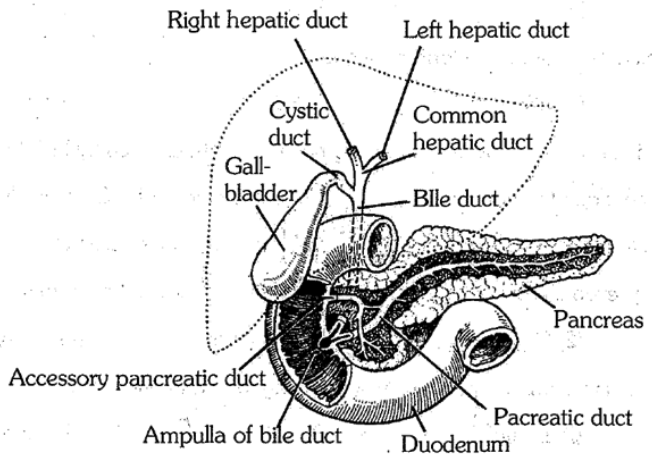
12. Monophyodont teeth are-
(1) Incisors and Canines (2) Canines and Premolars
(3) Premolars and Molar (4) Chanines and Molars

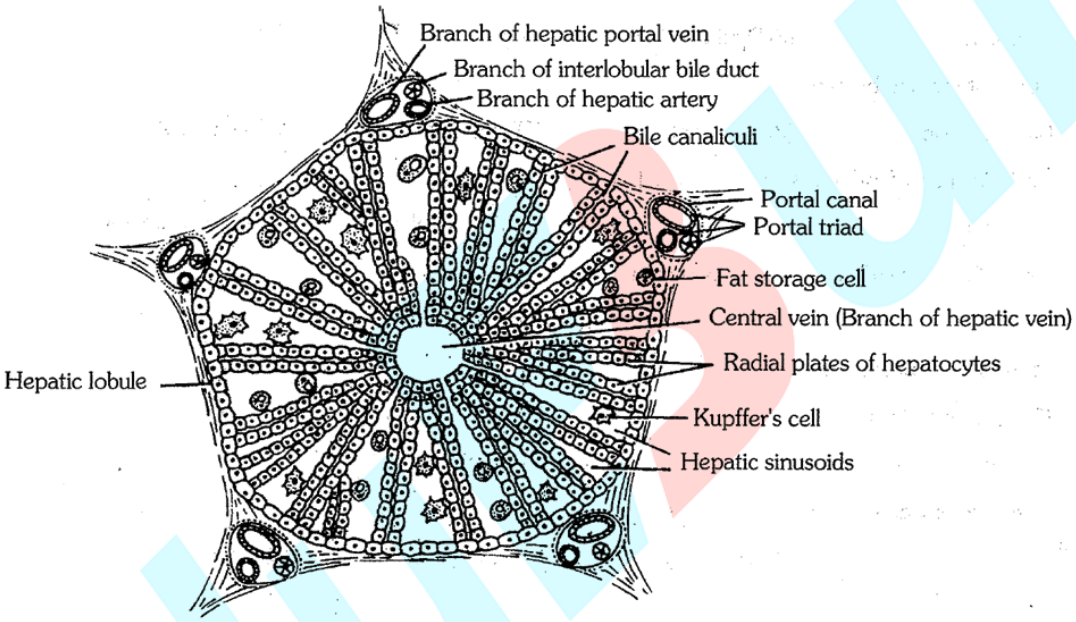
13. Presence of water amount in enamel is-
(1) 90 - 92% (2) 75 - 80% (3) 40 – 50% (4) ≈ 3%

ACCESSORY DIGESTIVE GLANDS

LIVER

- It develops from endoderm. (Weight 1.2 to 1.5 kg). 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 l/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.

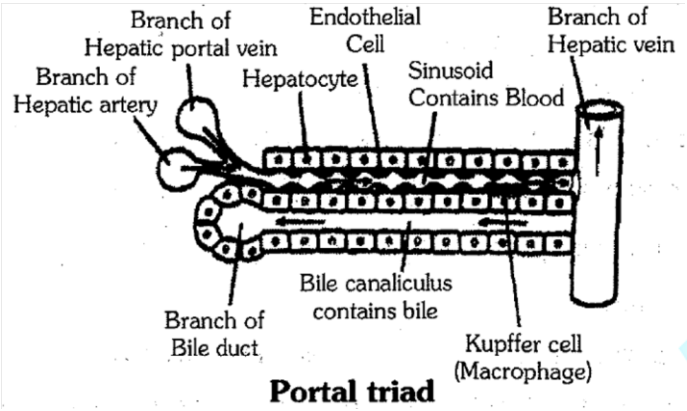




A part of transverse section of Hepatic lobule mammalian liver

- 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 a thin muscular sac 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.

HEPATIC LOBULE



Portal triad

- The functional and structural unit of liver is hepatic lobule.
- Each hepatic lobules are covered by a thin fibrous connective tissue sheath called as Glisson's capsule.
- Each lobule is consists of radial rows of hepatic cells (= hepatocytes) which are called as hepatic cord.
- 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.
- 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 are 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 as Portal triad.
- All hepatic sinusoids open into central vein or intralobular vein through fine aperture. All central vein combine to form hepatic vein which comes out from liver and opens into inferior vena cava.

FUNCTIONS OF LIVER :-

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

1. **Secretion and synthesis of bile -**
2. **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. 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.
   Glyconeogenesis : Synthesis of glycogen from lactic acid.
3. **Storage of fats-** Liver stores fats in a small amount.
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 are the phagocytic cells, helps in phagocytosis of dead blood cells and bacteria from the blood.
6. **Synthesis of plasma proteins-** All the plasma proteins except Gamma-globulins are synthesized in the liver. Prothrombin and fibrinogen proteins are also formed in hepatic cells. These help in blood clotting. Factors II, 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.
9. Liver stores vitamins A,D,E,K and B_{12}
10. **Storage of minerals-** Liver stores 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.
12. **Haemopoiesis-** The formation of blood cells is called haemopoesis. In embryonic stage R.B.C and WBC are formed by liver

BILE JUICE

Hepatocyte cells of the liver produces bile-juice and it is stored in the gall- bladder. Bile-juice does not contain any type of digestive enzyme, it is not called a true digestive juice.

Composition of bile. Organic constituents are (H_2O 98%), bile salt , bile pigment, cholesterol, Lecithin, 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 acidity of the food and make the medium basic.

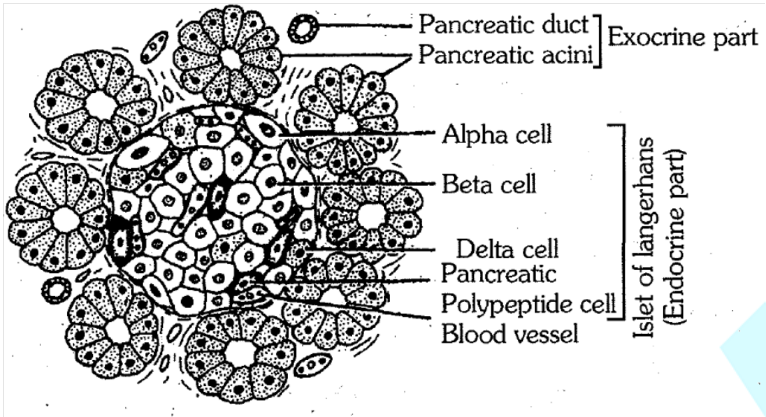
(b) **Organic salts-** Organic salts like Na-glycocholate and Na-taurocholate are found in bile juice. The main function of these salts is the emulsification of fats because pancreatic lipase can act only on emulsified fats. Bile salts also help in the absorPtion of fats and fat-soluble vitamins (A,D,E,K) bile salts combine with fats, cholesterol, phospholipid (lecithin) and these vitamins to form compounds called micelles.

FUNCTION OF BILE JUICE

- Neutralization of HCl.
- Emulsification. Sodium glycocholate and sodium taurocholate are bile salts which break the large fat droplets into the smaller ones.
- **Absorption of fat and fat-soluble vitamins.** Its salts help in the absorption of fat (fatty acids and glycerol) and fat-soluble vitamin (A, D, E and K).
- **Excretion.** Bile pigments (bilirubin and biliverdin) are excretory products.
- **Activation of lipase.** Bile contains no enzyme but activates the enzyme lipase.

Gall stone- Sometimes the passage inside the bile-duct gets blocked or becomes narrow, so the cholesterol gets deposited or precipitated in the gall-bladder to form gall stone (cholelithiasis).

PANCREAS



Section of heterocrine pancreas

- It develop from endoderm, pancreas is a mixed (Both exocrine and endocrine) organ situated between the limbs of the C-shaped duodenum. Its 99% part is exocrine while 1% part is endocrine.

Exocrine Part :-

- 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 enzymes 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 joins with the common bile duct to form the hepatopancreatic ampulla which opens into duodenum. This opening is guarded by sphincter of oddi. Opening of bile duct into pancreatic duct is controlled by sphincter of Boyden. The accessory pancreatic duct (duct of Santorini) opens into duodenum with separate openings located above the opening of main pancreatic duct.

Endocrine Part :-

- 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 pancreatic polypeptide hormone respectively.

PANCREATIC JUICE

- Pancreatic secretion of enzymes is stimulated by CCK and Ach while bicarbonate is stimulated by secretin.

  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-

  Pancreatic α - Amylase(= Amylopsin) dissociates starch into maltose. Majority of starch breaks up into the duodenum.

  Pancreatic proteases :

$$\text{Trypsinogen} \xrightarrow{\text{Enteropeptidase/Enterokinase}} \text{Trypsin}$$

$$\text{Chymotrypsinogens} \xrightarrow{\text{Trypsin}} \text{Chymotrypsins}$$

$$\text{Procarboxypeptidases} \xrightarrow{\text{Trypsin}} \text{Carboxypeptidases}$$

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

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

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

Fat digesting enzyme- In pancreatic-juices various fat digesting enzymes are found which are collectively 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.

BEGINNER'S BOX - 2

HISTOLOGY OF ALIMENTARY CANAL

1. Peyer's patches produce-
(1) Enterokinase (2) Lymphocyte (3) Mucous (4) Trypsin

2. Duodenum has characteristic Brunner's glands which secrete -
(1) Estrogen (2) Prolactin, parathormone
(3) Estradiol, progesterone (4) Alkaline fluid

3. Brunner's gland are found in which of the following layers :
(1) Submucosa of stomach (2) Mucosa of ileum
(3) Submucosa of duodenum (4) Mucosa of oesophagus

4. The crypts of lieberkuhn secrete :
(1) gastrin (2) rennin (3) cholecystokinin (4) succus entericus

5. Brunner's glands are located in :
(1) Oesophagus (2) Duodenum (3) Intestine (4) Stomach

6. Crypts of Lieberkuhn are present in:
(1) Small intestine (2) Stomach (3) Oesophagus (4) All of these

7. **Assertion (A) :** Thick layers of muscles are present in the wall of alimentary canal.
Reason (R) : These muscles help in the mixing of food materials with the enzymes coming from different glands in the alimentary canal.
(1) Both (A) and (R) are true and the (R) is correct explanation of the (A)
(2) Both (A) and (R) are true but the (R) is not the correct explanation of the (A)
(3) (A) is true statement but (R) is false
(4) Both (A) and (R) are false

PHYSIOLOGY OF DIGESTION

Digestion is divided in two ways-mechanical digestion and chemical digestion. Mechanical digestion takes place 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 chewing or mastication.

Chemical digestion

Ptyalin :-

- Starch $\xrightarrow[pH\,6.8]{Ptyalin}$ Maltose + α – Dextrin

Ptyalin is found in human saliva, because human food is mainly made up of starch. Ptyalin digest only ripe and cooked starch. It does not digest the raw starch. 30% starch in buccal cavity is digested by ptyalin.

- Bolus is pushed inward through the pharynx into the oesophagus this process is called swallowing or deglutition it is coordinated activity of tongue, soft palate, pharynx and oesophagus.
- Peristalsis is progression of coordinated contraction of involuntary circular muscles, which is preceded by a simultaneous contraction of the longitudinal muscle and relaxation of the circular muscle in the lining of gut.
- When a peristaltic wave reaches at the end of the oesophagus (digestive enzymes are absent in oesophagus) the cardiac sphincter (= Gastroesophageal sphincter) opens allowing the passage of bolus upto the stomach.

Gastroesophageal sphincter normally remains closed and does not allow food contents of the stomach to move back.

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.

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 hunan).

Digestion by pepsin

Inactive pepsinogen on getting proper pH converts into active pepsin.

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

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

- In stomach, endopeptidases are found, so digestion of proteins can take place 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.
- 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 chime
- After short intervals, the pyloric sphincter keeps on opening and closing so the chyme is fed into the intestine in instalments.

DIGESTION OF FOOD IN SMAIL 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 kind of mixing with digestive juice and bring food particle into contact of mucosa.

Chemical digestion :

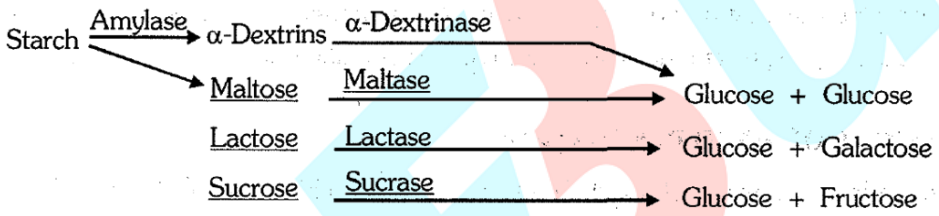
When food leaves the stomach through its pyloric end and enters the duodenum it is called chyme (acidic).

The intestinal mucosal epithelium has goblet cells which secrete mucus.

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

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.

$$\text{Large Peptides} \xrightarrow{\text{Aminopeptidase}} \text{Small peptides + amino acid}$$

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

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

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

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

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 lubricating it for an easy passage.

(iii) E. coli (bacterium) lives in the colon which feeds on undigested matter. This bacterium, in turn produces Vitamin - B_{12}, B_l, 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 through ileo-caecal valve, which prevents the back flow of the faecal matter. It is temporarily stored in the rectum till defaecation.

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	Stomach	Proteins	Large peptides
Pancreatic Juice (Pancreas)			
Pancreatic α-amylase	Small intestine	Starch	Disaccharides
Trypsin	Small intestine	Proteins	Large peptides
Chymotrypsin	Small intestine	Proteins	Large peptides
Carboxypeptidases	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	Small intestine	Large peptides	Amino-acid
Peptidase	Small intestine	Oligopeptides	Amino acids
Disaccharidases	Small intestine	Disaccharides	Monosaccharides
Nucleotidase	Small intestine	Nucleotides	Nucleosides 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
1.	Gastrin	Pyloric stomach and duodenum (G-cells)	Vagus nerve activity; peptides and proteins in stomach.	Secretory cells and muscles of stomach; secretion of HCl and stimulation of gastric motility.
2.	Cholecystokinin (CCK)	Duodenum (I-cells) or CCK cells	Food (fatty chyme and amino acids) in duodenum.	Gall bladder; contraction of gall bladder (bile release)
3.	Secretin	Duodenum (S cells)	Food and strong acid in stomach and intestine.	Secretion of water and bicarbonate from pancreas inhibition of gastric motility. It stimulate liver for the secretion of bile juice
4.	Gastric Inhibitory Peptide (GIP)	Duodenum	Monosaccharides and fats (fatty chyme) in duodenum.	Gastric mucosa and muscles; inhibition of gastric secretion and motility (slowing food passage).
5.	Duocrinin	Duodenum	acidic chyme	Stimulate Brunner's gland to secrete alkaline mucus.
6.	Enterocrinin	Duodenum	...	Stimulate paneth cells for synthesis and secretion of enzymatic part of intestinal juice.
7.	Villikinin	Duodenum	...	It stimulates the activity of villi.
8.	Vasoactive intestinal peptide (VIP)	Duodenum	...	They inhibits the motility of stomach
9.	Enterogasterone	Duodenum	...	Inhibit secretion of gastric glands

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 gradients. However, some of the substances like glucose and some amino acids are absorbed with the help of the carrier proteins. 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.

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.

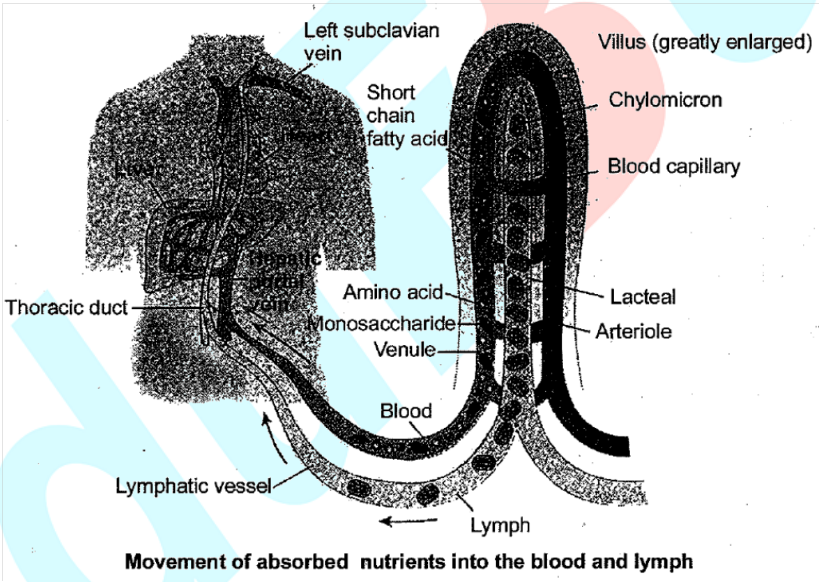
Absorption of Carbohydrate

- 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) because concentration of glucose is higher in lumen.

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 –

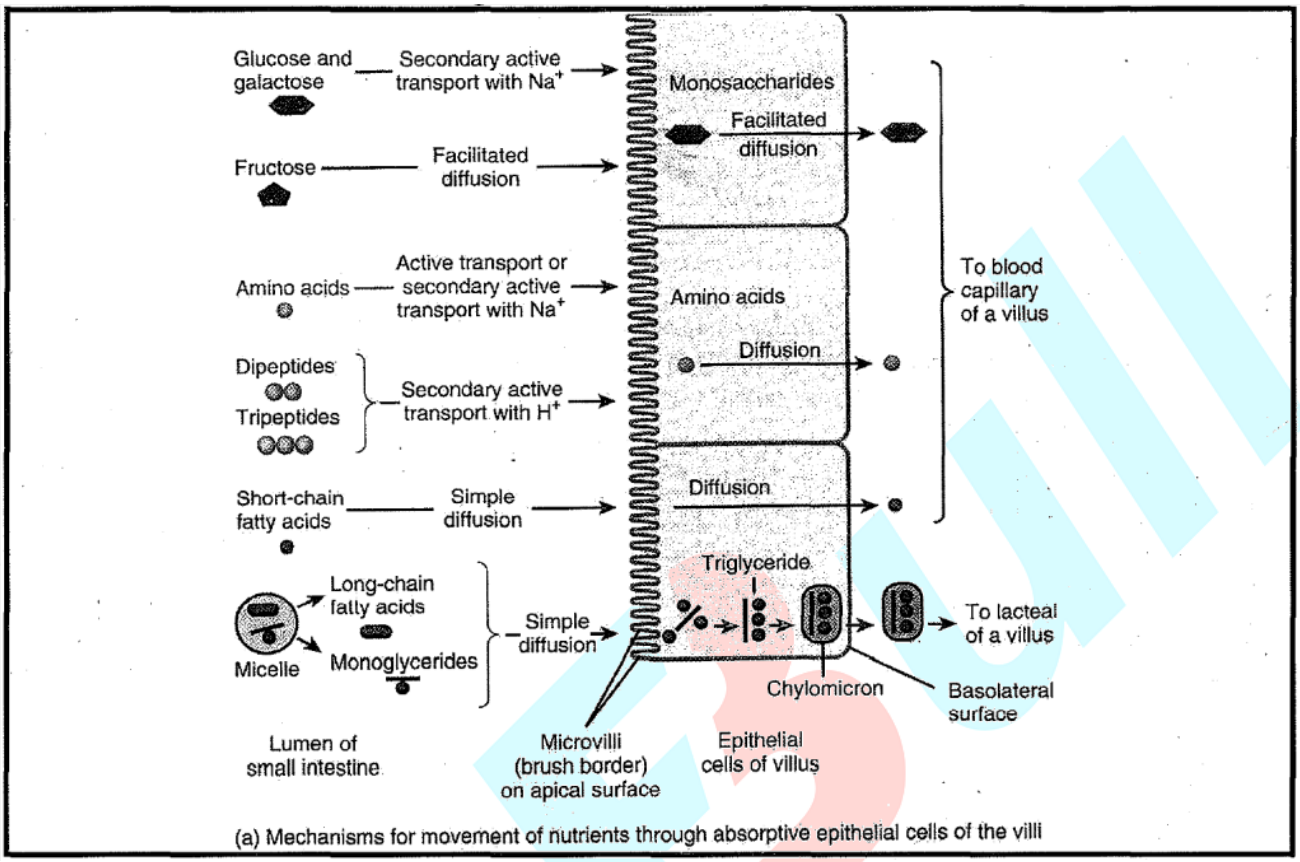


Movement of absorbed nutrients into the blood and lymph

- 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 chylomicro (150 μm, white). Chylomicron enters into the lacteal.
- Fat soluble vitamins are absorbed along with dietary fat whereas water soluble vitamins are absorbed by passive diffusion. Vitamin B_{12} is absorbed with intrinsic factor by forming a complex.

Absorption in colon

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



(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 Intestine
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 sugar 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 of water, some minerals and drugs takes place

ASSIMILATION

- The absorbed substances finally reach the tissues which utilise them for their activities. This process is called assimilation.

EGESTION (DEFAECATION)

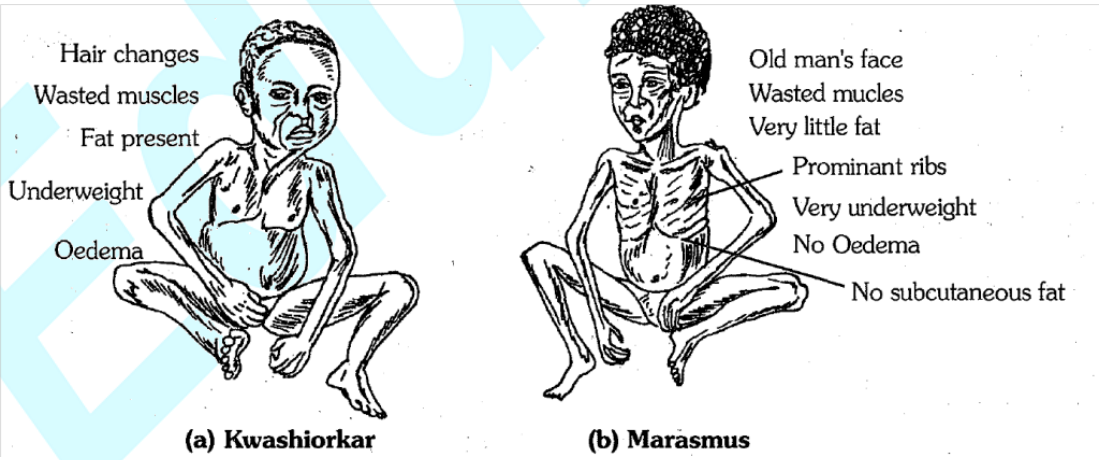
- The elimination of faeces from the alimentary canal is called egestion or defaecation.

- 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.
- Peristalsis gradually pushes the indigestible materials of the small intestine into the large intestine or colon. Normally 1500 ml of chyme passes into the large intestine per day. The colon absorbs most of the water. It also absorbs electrolytes, including sodium and chloride from the chyme. The epithelial cells of the colon also excrete certain salts such as iron and calcium from the blood.
- As the faeces reach anus the anal sphincters relax to allow its discharge (defaecation). The external anal sphincter is under voluntary control whereas the internal anal sphincter is involuntary. In infants the defaecation occurs by reflex action without the voluntary control of the external anal sphincter.
- Colour of the faeces is due to pigment - stercobilin. It is formed by degradation of bilirubin. Foul smell of the excreta is due to indole, scatole and H_2S. These are formed in the colon due to the decomposition of amino acids by bacteria.

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.

PROTEIN ENERGY MALNUTRITION (PEM)



Protein Energy Malnutrition (PEM)

	Kwashiorkar	Marasmus
1.	Occur in child more than one year of age	Occur in Child below one year
2.	Deficiency of proteins only	Deficiency of protein and calories both
3.	Extensive oedema	No oedema

4.	Subcutaneous fat is still present	Subcutaneous fat disappear
5.	Warring of muscles and thinning of limbs occur	Extreme emaciation of body and thinning of limbs occur
6.	Skin appear to be swollen	Skin is dry and wrinkled
7.	Underweight children	Severely emaciated

In both Kwashiorkar and marasmus physical growth and mental development is effected.

Protein-energy malnutrition (PEM) :

Dietary deficiencies of proteins and total food calories are widespread in many underdeveloped countries of South and South-east Asia. South America and West and Central Africa. Protein-energy malnutrition (PEM) may affect large sections of the population during drought, famine and political turmoil. This happended in Bangladesh during the liberation war and in Ethiopia during the severe drought in mid-eighties. PEM affects infants and children to produce Marasmus and Kwashiorkar.

Marasmus is produced by a simultaneous deficiency of proteins and calories. It is found in infants less than a year in age, if mother's milk is replaced too early by other foods which are poor in both proteins and caloric value. This often happens if the mother has second pregnancy or childbirth when the older infant is still too young. In Marasmus protein deficiency impairs growth and replacement of tissue proteins; extreme emaciation of the body and thinning of limbs results the skin becomes dry thin and wrinkled. Growth rate and body weight decline considerably. Even growth and development of brain and mental faculties are impaired.

Kwashiorkar is produced by protein deficiency unaccompanied by calorie deficiency. It results from the replacement of mother's milk by a high calorie low protein diet in a child more than one year in age. Like marasmus, kwashiorkor shows wasting of muscles, thinning of limbs, failure of growth and brain development. But unlike marasmus, some fat is still left under the skin, moreover, extensive oedema and swelling of body parts are seen.

Calorific value :

- The amount of heat liberated from complete combustion of 1 gm food in a bomb calorimeter (a closed metal chamber filled With O_2) is its gross calorific value or gross energy value (G.C.V.).
- The actual amount of energy liberated in the human body due to combustion of 1 gm of food is the physiologic value (P.V.) of food.

Food substance	G.C.V. (in K. Cal/gm)	P.V. (in K. Cal/gm)
Carbohydrate	4.1	4.0
Protein	5.65	4.0
Fats	9.45	9.0

VITAMINS

Earliest extracted vitamin = Vitamin – B

Vitamins are following types –

(1) Fat soluble vitamin : A, D, E, K (2) Water soluble vitamin : B-complex and 'C'

Vitamin	Common name	Source	Deficeincy desease	Symptoms	Functions
B_1	Thiamine	Wheat, Gram, Peanuts,	Beri-beri/ Polyneuritis/ Cardio	Loss of appetite, Fatigue,	Form coenzymes in carbohydrate metabolism and

		Yeast, Beans	vascular atrophy	Muscle, Atrophy, Paralysis, Cardiomegaly	help in pentose metabolism
B_2	Riboflavin vitamin-G or Yellow Enzyme	Yeast, Liver, Milk, Cheese, Leafy Vegetables and Intestinal Bacteria	Cheilosis, Glossities, Keratitis	Eye Inflammation and Lip sores	Part of coenzymes (FMN and FAD) in ETC
B_3	Niacin/ Vitamin A-D/ PP-Factor	Yeast Gram, Peanuts and Meat	Pellagra, Diarrhoea, Dermatitis, Dementia, Death (4-D Syndrome)	Scaly skin, Dehydration, Loss of Memory	Part of coenzymes NAD and NADP that acts as hydrogen acceptors and donors for functioning of gastro-intestinal tract and nervous system
B_5	Pantothenic acid, Yeast Factor	Yeast Peas, Liver, Max in Wheat Honey	Burning feet syndrome	Abnormal Adrenal functioning, Nerve degeneration	Part of coenzyme A in cell respiration, require fro nerve for mation, Formation of actylcholine, For normal adrenal gland
B_6	Pyridoxine	Meat Milk, Wheat, Liver, Banana	Nausea and Vomiting	Skin lesion, CNS disorders and convulsions	Part of coenzymes pyridoxal phosphate require in formation of amino acids and glycogen synthesis
B_9	Folic acid/ Folacin/ Vitamin-M	Liver, Green Vegetables, Banana and Oranges	Macrocytic anaemia	Impairment of antibody synthesis and stunted growth Ulceration in mouth	Part of coenzymes in nucleic acid (Purine and pyrimidine) synthesis and protein synthesis, Erythropoiesis, Cell division in bone marrow
B_{12}	Cyano - Cobalamine	Liver and Eggs	Pernicious anaemia (Megalo blastic anaemia)	Large and immature RBC nucleated RBC's without hemoglobin	Coenzymes for nucleic acid synthesis
C	Ascorbic Acid	Amla, Citrus fruits,	Scurvy, Anaemia,	Bleeding Gums, Loose	Play an important role in collagen

		Tomatoes	Joint pain	teeth, anemia and painful swollen joints	formation, functioning of adrenal gland, anti-oxidant, erythropoiesis, absorption of Ca^{+2} and Fe^{+2}
D	Calciferol	Fish oil, Liver, Egg yolk, Milk	Rickets in children and Osteomalacia in Adults	Weak and Soft bones, distorted skeleton and poor	Facilitates Ca and P absorption by intestine
E	Tocopherol/ Antisterility / Beauty Vitamin	Leafy Vegetables, Cereals and Vegetable oils	Macrocytic Anaemia, Muscular dystrophy	Destruction of RBC	Antioxidant and plays an important role in ETS, Selenium metabolism, formation of RNA, DNA and RBC
A	Retinol	Yellow and Green Vegetables, Fruits, Milk and Butter	Nightblindness (Nyctalopia) Xeropthalmia Dermatitis	Keratinisation of skin, respiratory and urinogenital tract	Prevent keratinisation of epithelia
K	Menadione/ Phylloquinone	Leafy Vegetables, Soyabean oil and Intestinal Bacteria	Severe bleeding	Slow or delayed blood clotting	Synthesis of prothrombin for normal blood clotting, Present in intestinal bacteria
H	Biotin/ Vitamin-B/ Antiavidin	Vegetables and Fresh Fruits, Liver, Milk, Eggs	Dermatitis	Scaly skin Muscle pain and weakness	Coenzyme in fatty acid synthesis and changes of pyruvate into OAA

WANNING STROKE

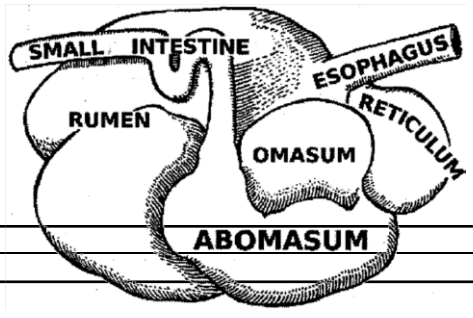
1. Nature's most potent antioxidant - vitamin E, which is maximum in liver.

2. Vitamin B_{12} is absent in plants, However it is considered that Spirulina (an algae) contains B_{12}.

3. Anticancer vitamins-A, B_1 , C etc.

Compound stomach/ Ruminant stomach

Stomach of ruminant animals are made up of 4 chambers:



(i) Rumen (paunch) : Largest chamber

(ii) Reticulum (honey comb) : Smallest chamber
(iii) Omasum (psalterium) Omasum is absent in camel and deer.
(iv) Abomasum (Rennet): True stomach.
Gastric juice-secreted by abomasum. So it is called true stomach. Inner surface of rumen and reticulum lined by keratinised epithelium. Symbiotic bacteria found in rumen and reticulum. Voluntary muscles found in rumen and oesophagus. Hence reverse peristalsis are found in rumen and oesophagus which is controlled by will power of animal.

SOME IMPORTANT MINERAL, THEIR EFFECT OF DEFICIENCY AND FUNCTIONS

Mineral	Effect of deficiency	Functions
Calcium	Rickets, muscular spasm (Vitamin-D is also required)	Component of bone and teeth; Essential for normal blood clotting; needed for normal muscle and nerve function, and Heart function (Vitamin-D is also required)
Chlorine	Anorexia, muscular cramp	Principal anion of interstitial fluid; Important in formation of HCl and acid-base balance,
Magnesium	Muscle convulsion in intestine	Enzyme activator. Required in muscle relaxation, Ribosome binding and nerve function
Iodine	Goitre, Abortion, infant death, Cretinism	Component of thyroid hormone.
Iron	Anaemia, weak immunity	Components of respiratory pigments (like haemoglobin and myoglobin), respiratory enzymes (like cytochromes) and oxygen transport enzymes.
Phosphorus	Deformaiton of bone and teeth, retarded body growth and physiological function	Important structural component of bones, DNA and RNA; essential in energy transfer, storage of energy (ATP) and other metabolic activities; maintains normal blood pH (buffer action.)
Potassium	Rickets, Risk of paralysis	Principal cation in the cytoplasm; controls nerve excitability and muscle contraction. Dietary deficiency causes rickets among children.
Sodium	Muscular cramp. Hypotension and Aneroxia	Principal cation of interstitial fluid; maintains fluid balance; essential for conduction of nerve impulse. Component of bile salt, helps in absorption of glucose, fructose and few amino acid.
Sulphur	Skin patches, disturb metabolism	Components of hormones (e.g. insulin); necessary for normal metabolism and present in amino acid like methionine, cysteine.
Zinc	Weak immunity and fertility, Retarted growth and Anorexia	Component of at least 70 enzymes, like carbonic anhydrase and some peptidases.
Copper	Aneamia and damage of CNS	Component of enzymes for melanin synthesis; Essential for haemoglobin synthesis. Component of cyt-$a_3$in ETS (Cytochrome oxidase).
Cobalt	Pernicious anaemia	Component of Vitamin-B_{12} and erythropoiesis.
Chromium	Diabetes mellitus and Irregular ATP	Normal activity of insulin, carbohydrate and lipid metabolism

	production	
Selenium	Male infertility, prostate cancer, liver necrosis and muscular dystrophy	Maintains enamel and checks dental decay by formation of flourapeptite. Antibacterial
Manganese	Irregular growth of bone, cartilage, connective tissue, anaemia.	Functioning of lipase enzyme, urea synthesis, needed for haemoglobin synthesis, releases insulin, lactation, bone formation.
Molybedenum	Irregular excretion of nitrogenous waste	Co-factor in some enzyme, formation of ascorbic acid.
In minerals tables Trace element are fluorine, zinc, copper, manganese, cobalt, selenium, chromium and molybedenun.		

BEGINNER'S BOX - 3

DIGESTIVE GLANDS

1. Islets of langerhans _____ and are found in _____
(1) Modified lymph glands, pancreas (3) Specialized area, pituitary
(2) Ductless glands, pancreas (4) Small tubules, kidney

2. Ptyalin is secreted by _____ and work in _____ medium.
(1) Stomach, acidic (2) Salivary gland, almost neutral medium
(3) Pancreas, alkaline (4) Bile, alkaline

3. In pancreas, pancreatic juice and hormone are secreted by-
(1) Same cells (2) Different Cells
(3) Same cells at different times (4) None of these

4. Largest gland of body -
(1) Pancreas (2) Duodenum (3) Liver (4) Thyroid

5. Insulin is secreted by pancreatic cells-
(1) α-cells (2) β-cells (3) Delta cells (4) Gamma cells

6. Which substance of saliva destroy the harmful bacteria-
(1) Cerumin (2) Chyme (3) Lysozyme (4) Secretin

7. Which of the following is not a function of liver :-
(1) Deamination (2) Bile storage
(3) Synthesis of plasma protein (4) Storage of fat soluble vitamin

8. The glucose is converted into glycogen in liver and stored in :
(1) Liver (2) Liver and muscles
(3) Liver and spleen (4) Spleen and muscles

9. Kupffer cells are found in :
(1) Liver (2) Kidney (3) Heart (4) Blood

ANSWERS KEYS

BEGINNER'S BOX - 1

1.	(1)	**2.**	(1)	**3.**	(2)	**4.**	(4)	**5.**	(1)	**6.**	(3)	**7.**	(1)
8.	(1)	**9.**	(1)	**10.**	(3)	**11.**	(2)	**12.**	(3)	**13.**	(4)		

BEGINNER'S BOX - 2

1.	(2)	**2.**	(4)	**3.**	(3)	**4.**	(4)	**5.**	(2)	**6.**	(1)	**7.**	(1)

BEGINNER'S BOX - 3

1.	(2)	**2.**	(2)	**3.**	(2)	**4.**	(3)	**5.**	(2)	**6.**	(3)	**7.**	(2)
8.	(2)	**9.**	(1)										