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PRE-MEDICAL

ZOOLOGY

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STUDY MATERIAL

Digestion and Absorption

ENGLISH MEDIUM

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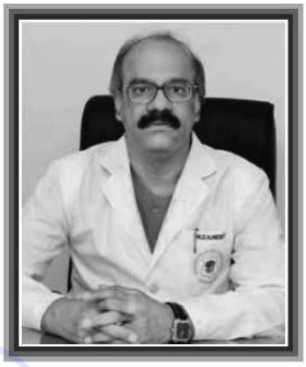

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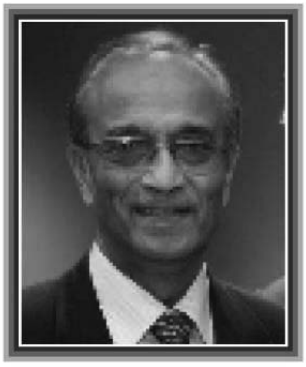
DR. RAMESH ROOP RAI is a well experienced and senior consultant Gastroenterologist associated with Fortis Hospitals, Jaipur. He is the first DM Gastroenterologist in Rajasthan, he worked in various projects and has published over 98 research papers in National & International Journals. He has been instrumental in designing and manufacturing for various procedures of Gastroenterology. Dr. Ramesh was elected as the president of Indian Society of Gastroenterology 2007-2008, he was a pioneer to start first DM course in Gastroenterology SMS Medical College, Jaipur.



Over the years, **DR. RAKESH TANDON** has won many discrete awards for his contribution, hard work and commitment towards providing patients a new lease of life.Dr. Rakesh Tandon has been awarded by the Medical Council of India, has Dr. B.C.Roy Award for being Eminent Teacher, Gold medal for best thesis in M.D. (Medicine) and many more. Dr. Rakesh Tandon publications are read all over the world because he is not restricted to writing for only Indian audiences. Dr. Rakesh Tandon has authored some well known and bestselling books.

Dr. Rakesh Tandon has MBBS, MD (General Medicine), done PhD from AIIMS, FAMS, FICP and FRCP from Royal College of Surgeons, Edinburgh, UK. This clearly shows he has superior knowledge and uses it well in every medical issue that Dr. Rakesh Tandon deals with. His creative ideas have helped patients enormously.

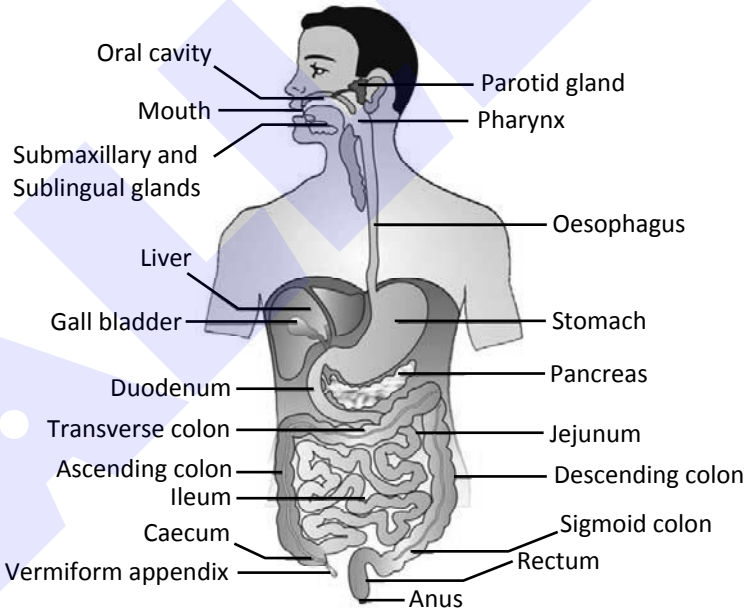
DIGESTION AND ABSORPTION

01. INTRODUCTION

- **Introduction**
- **Digestive System**
- **Digestion of Food**
- **Absorption of Digested Products**
- **Disorders of Digestive System**

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 absorbable forms is called digestion and is carried out by our digestive system by mechanical and biochemical methods.



The human digestive system

NCERT XI, Page No. 258, Figure No. 16.1

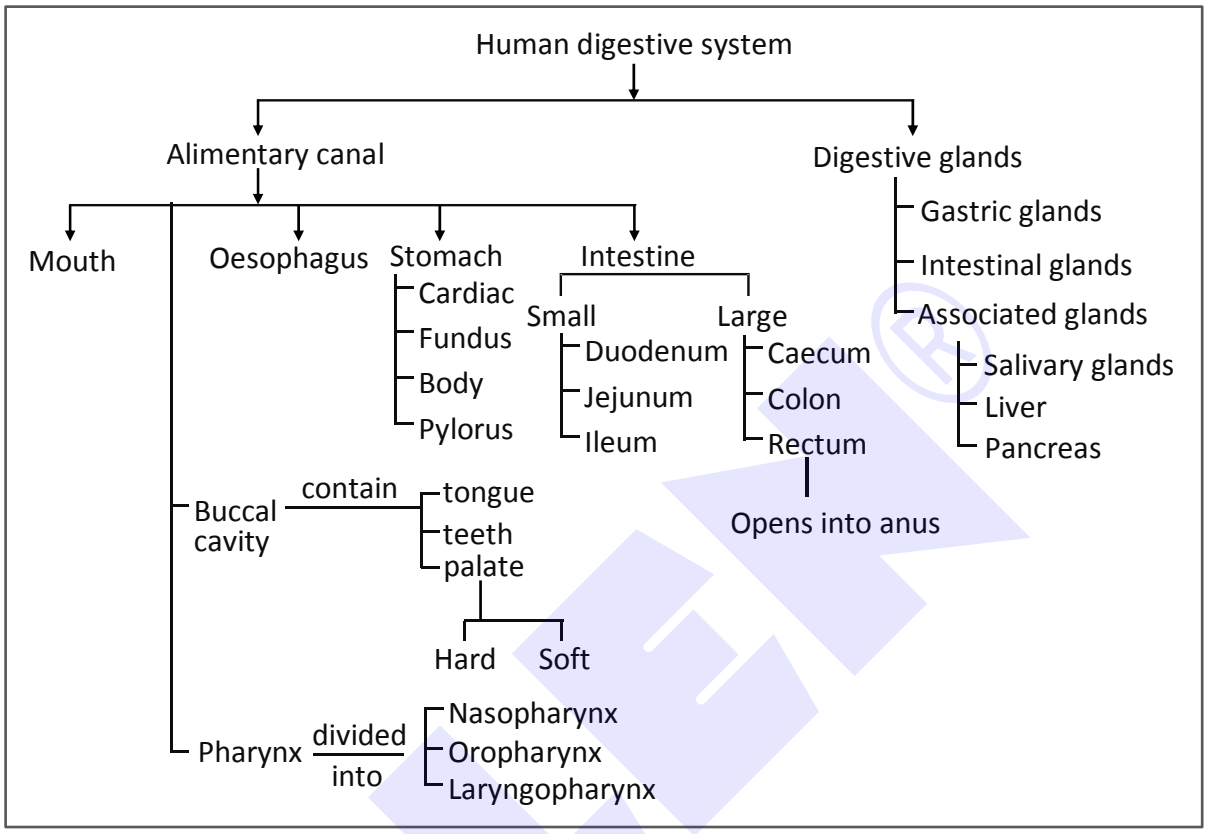
Origin of alimentary canal

- The alimentary canal is tubular structure which extends from mouth to anus.

02. DIGESTIVE SYSTEM

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

ANATOMY OF ALIMENTARY CANAL



(1) ALIMENTARY CANAL

The alimentary canal begins with an anterior opening – the mouth, and it opens out posteriorly through the anus.

(A) Mouth and Buccal Cavity :

Mouth is a horizontal transverse slit like aperture which is surrounded by upper and lower lip. Lips are movable.

- The mouth leads to the buccal cavity.

  (i) Buccal vestibule – The space between the gums and cheeks where the food is stored temporarily.

  (ii) Oral cavity – The oral cavity has a number of teeth, a muscular tongue and palate. It is inner & central part which is surrounded by upper and lower jaw, lined by non keratinized stratified squamous epithelium. Upper Jaw is fixed and lower jaw is movable.

  (iii) Palate

  The roof of oral cavity is called **Palate**.

  Palate is differentiated into two parts :

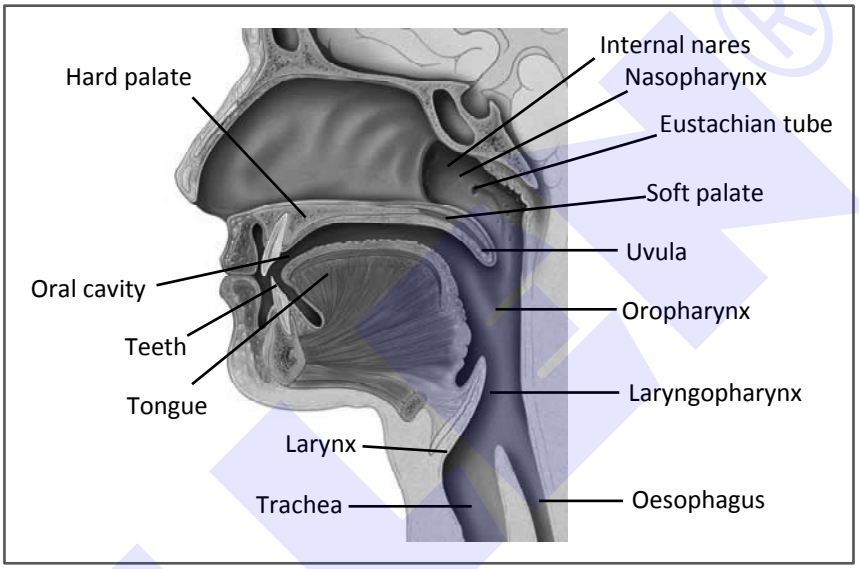
(a) Hard Palate –

- 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 projections or transverse ridges are present which are called **palatine rugae.**

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

(b) Soft Palate –

It is the posterior part of palate.



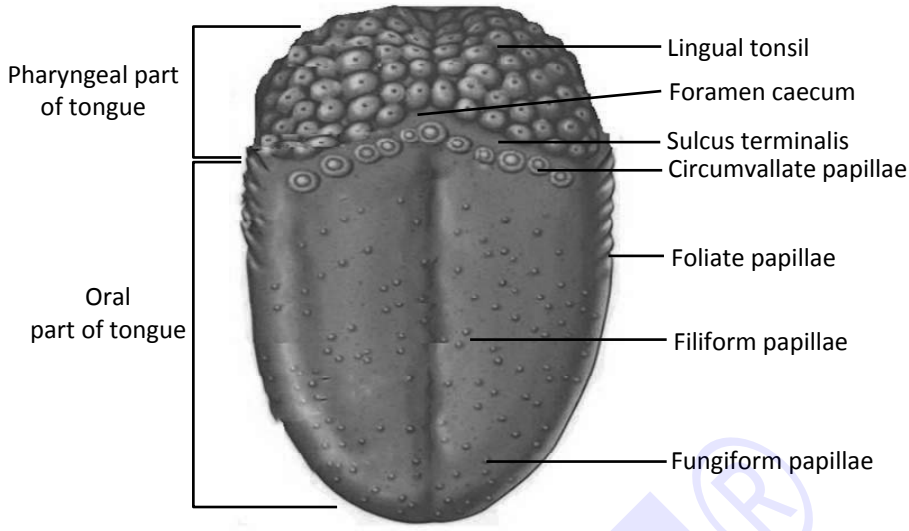
- The posterior outgrowth of soft palate which hangs down in the form of finger like process called as **Uvula** or **Velum palati**. On the upper side of uvula one pair internal nostrils are present.

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

- One pair of large lymph node is present on the posterolateral surface of soft palate, called as **Palatine tonsil** or **Tonsils**.

(iv) Tongue :-

- The tongue is a freely movable muscular organ attached to the floor of the oral cavity by the frenulum. The upper surface of the tongue has small projections called papillae, some of which bear taste buds.



Upper surface of human tongue

- The anterior part of tongue is free while posterior part of tongue is connected to the Hyoid bone.
- On the dorsal surface of tongue, it is divided into two unequal parts by a V shaped sulcus, called sulcus terminalis.

  The two limbs of the 'V' meet at a median pit named **Foramen caecum**.

  Tongue is divided into two parts –
- **Pharyngeal part** – It is the posterior 1/3 part of the tongue. Many small lymph nodes are present in this part which are called **Lingual tonsil**.
- **Oral or papillary part** – It is anterior 2/3 part of tongue. Papillae are found in this part in which gustatory or taste receptors are present in the form of taste buds on few papilla.
  - **Fungiform Papillae –**

    It is pink coloured, small & 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.
  - **Filliform papillae (Conical papillae) –**

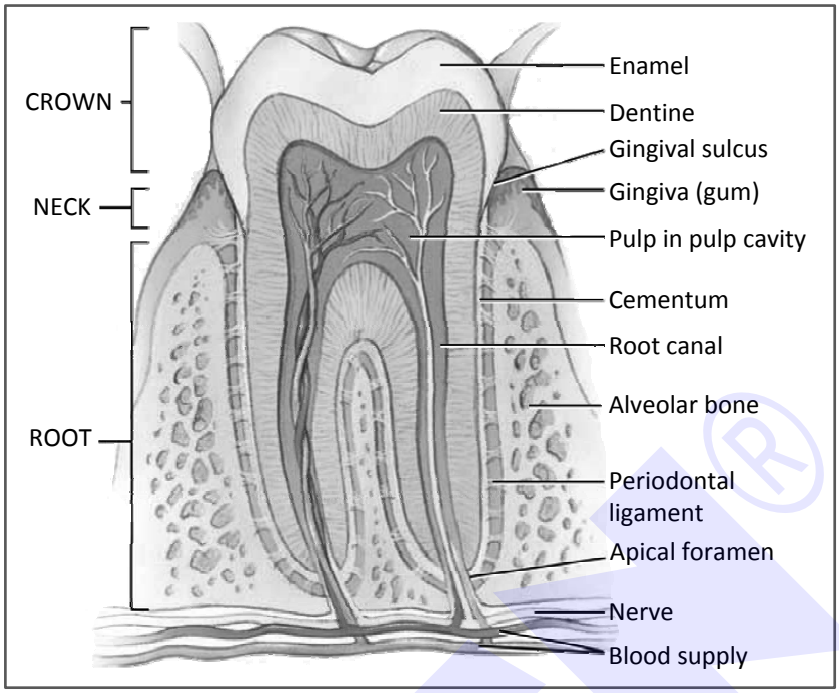
    They are thread like, white coloured & conical in shape. They are also found on the entire surface of tongue. They are most numerous, but devoid of taste buds.
  - **Circumvallate papillae –**

    These are largest and least existed papillae (8 to 12). They are large spherical shape papillae which are found near sulcus terminalis.

Foliate papillae –

They are found on the mid lateral surface of tongue. They are vestigeal in the human. Their structure is leaf like, they are functional in rabbit and other mammals.

(v) Teeth :-



- Teeth are **ectomesodermal in origin**.

In human beings three basic features of teeth are Thecodont, diphyodont, heterodont

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

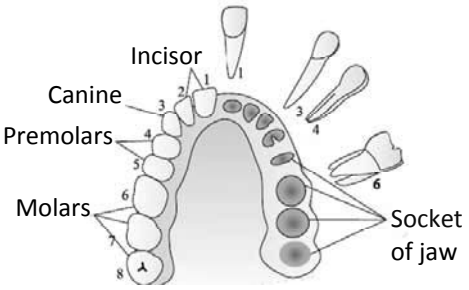
Majority of mammals including human being forms two sets of teeth during their life, a set of temporary milk or deciduous teeth replaced by a set of permanent or adult teeth. This type of dentition is called diphyodont. An adult human has 32 permanent teeth which are of four different types (Heterodont dentition), namely, incisors (I), canine (C), premolars (PM) and molars (M). Arrangement of teeth in each half of the upper and lower jaw in the order I, C, PM, M is represented by a dental formula which in human is $\frac{2123}{2123}$. The hard chewing surface of teeth, made up of enamel, helps in the mastication of food.

Dental formula :-

Child = $I\frac{2}{2}C\frac{1}{1}PM\frac{0}{0}M\frac{2}{2}=\frac{5}{5}\times2=\frac{10}{10}=20$

17 Yr. old = $I\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{2}{2}=\frac{7}{7}\times2=28$

Adult = $I\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{3}{3}=\frac{8}{8}\times2=\frac{16}{16}=32$



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

NCERT XI, Page No. 259, Figure No. 16.2

Four types of teeth found in mammals are –

(a) **Incisor-** These are long, chisel like teeth for **gnawing** the food. They are more developed in gnawing animals e.g. rodents.

Tusk of elephant are modification of upper incisor.

(b) **Canines-** These are sharp pointed teeth meant for tearing and shredding the food. Canines are more developed in carnivorous animals.

Canines are absent in herbivorous animals. In herbivores, the space of canine in gums is empty and this empty space is called diastema.

(c) **Pre molars -** These teeth are meant for chewing and crushing of food. They are triangular in shape.

(d) **Molars** – These also meant for chewing & crushing of food. They are rectangular in shape.

- In humans, 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 milk teeth are shed, then permanent teeth appear.

  Cheek teeth - Premolars and molars.

  In humans, premolar teeth appear in the alveoli of molar teeth while permanent molar teeth are developed in new alveoli.

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

- **Monophyodont** :- The teeth which appear only once in life.
  eg. **Premolars and last molars of human.**
- **Diphyodont** :- The teeth which appear twice in life. eg. **Incisors, Canines, 1st and 2nd molars.**
- **Thecodont** :- The teeth which are present in bony socket of Jaw.
  eg. **Mammals and Crocodile.**
- **Heterodont** :- When the teeth are of four different type in mammals on the basis of structure and function.

Fluoride maintain enamel and checks dental decay.

(B) Pharynx :

- The oral cavity leads into a short pharynx which serves as a common passage for food and air. The oesophagus and the trachea (wind pipe) open into the pharynx. A cartilaginous flap called epiglottis prevents the entry of food into the glottis – opening of the wind pipe – during swallowing.
- 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.

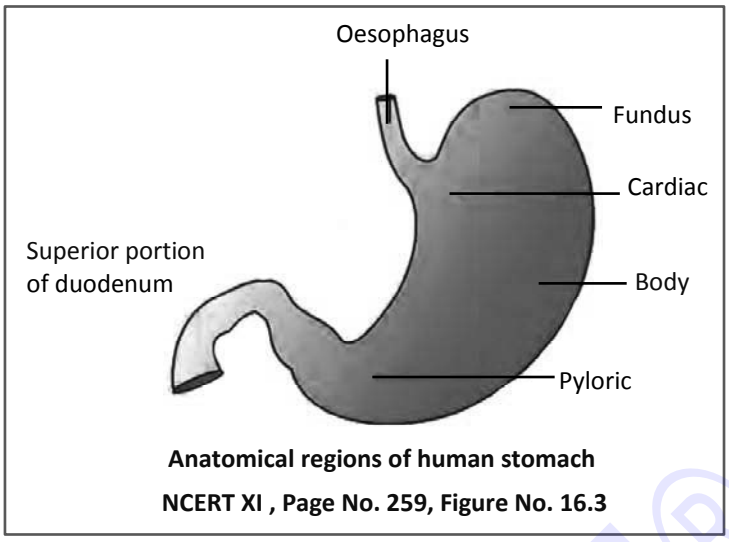
(C) Oesophagus :

Two apertures are found in pharynx.

- Ventral aperture is called **Glottis** which is related to the larynx which is guarded by a cartilaginous flap epiglottis.
- The dorsal aperture is called **gullet** which opens into oesophagus.
- The oesophagus is a thin, long tube which extends posteriorly passing through the neck, thorax and diaphragm and leads to a 'J' shaped bag like structure called stomach. A muscular sphincter (gastro-oesophageal) regulates the opening of oesophagus into the stomach. The oesophageal hiatus is an opening in the diaphragm through which the oesophagus and the vagus nerve pass.
- In oesophagus digestive glands are absent, only mucous glands are present in mucosa.
- The length of oesophagus depends on length of neck so the longest Oesophagus is present in Giraffe.

(D) Stomach :

- It is situated on left side of abdominal cavity. **It is the widest part of alimentary canal**. It is a J shaped bag like muscular structure.
- The stomach contains four parts (Cardiac, Fundic, Body, Pyloric) - A cardiac portion into which the oesophagus opens, a fundus region, body main central region and a pyloric portion which opens into the first part of small intestine.
- It has two orifices (opening)
  - **Cardiac orifice** is joined by the lower end of the oesophagus.
  - **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 Ommentum.



Anatomical regions of human stomach

NCERT XI , Page No. 259, Figure No. 16.3

- Mucous membrane of the stomach is thick. In empty stomach numerous temporary longitudinal folds are found in mucosa of stomach called rugae. They disappear when stomach is distended.
- **Gastric Glands :-** These are numerous microscopic, simple branched tubular glands formed by the invagination of epithelium (mucosa) in the stomach. The following types of cells are present in the epithelium of the gastric glands.
  - Mucous neck cells
  - Oxyntic cells or parietal cells
  - Chief cells or peptic cells or Zymogen cells

Consist of 4 types of

- Mucous cells —secrete→ mucus - protect inner lining of stomach from action of HCl
- Parietal cells (Oxyntic cells) → Castle Intrinsic Factor - helps in absorption of vitamin B_{12}.
  → HCl (pH = 1.8) -
  (1) inactivate ptyalin
  (2) Kill bacteria present in bolus
  (3) Convert inactive enzymes into active enzymes
  (4) Provide acidic medium in stomach
  (5) Softens food particles
- Peptic cells (Chief cells/ Zymogen cells)
  - Gastric lipase - convert 1% emulsified fats already present in our food into fatty acids and monoglyceride
  - Pepsinogen —HCl→ Pepsin
  - Prorennin (In infants) —HCl→ Rennin
- Enteroendocrine cells → Gastrin - stimulate the secretion of gastric juice

(E) Intestine :

It is divided into two part

(i) Small intestine (ii) Large intestine

(i) Small intestine

- Small intestine is distinguishable into three regions, a 'C' shaped duodenum, a long coiled middle portion jejunum and a highly coiled ileum. The opening of the stomach into the duodenum is guarded by the pyloric sphincter.
- For absorption of digested food a very large surface area is required. Therefore some adaptations are present here.
  - Great length of the intestine.
  - Villi and microvilli (Brush border).

(ii) Large intestine

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

(a) Ceacum

- Ileum opens into the large intestine.
- The lower end of the ileum opens into caecum at the **Ileo-caecal junction**. The Ileocaecal opening is guarded by **Ileocaecal valve**. Caecum is a small blind sac. Which hosts some symbiotic microorganisms.
- About 2 cm below the ileocaecal orifice, a narrow finger like tubular projection arises from the caecum called as **vermiform appendix**. It is a vestigial organ. Caecum is well developed in rabbit and other herbivore mammals but is vestigial in human.

(b) Colon

- Caecum opens into the **colon**, which is the middle part of large intestine.
- The longitudinal muscle coat forms three ribbon like bands called **Taeniae coli**. Due to the presence of taeniae, pouch like structure develops in Lumen of colon called as **Haustra**. Colon has following parts in human – an ascending, a transverse, descending part and a sigmoid or pelvic colon.

(c) 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**.
- 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 $\longrightarrow$ Involuntary

External Anal sphincter $\longrightarrow$ Voluntary

BEGINNER'S BOX — ANATOMY OF ALIMENTARY CANAL

1. Dental formula of adult human is -
(1) $\frac{2123}{2123}$ (2) $\frac{2123}{2122}$ (3) $\frac{2123}{2124}$ (4) $\frac{2132}{2132}$

2. In Colon, constrictions of its wall form a series of small pockets called-
(1) Haustra (2) Crypts of Lieberkuhn
(3) Zymogen cells (4) Taeniae

3. pH of stomach in human is about-
(1) 7 (2) 1.8 (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) Neutralization of HCl by alkaline gastric juice.
(3) HCl being dilute (4) Epithelium being resistant to HCl

6. The structure which prevents entry of food into wind pipe 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) By uvula (2) By palate (3) By tongue (4) None of these

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

13. What do you mean by the process of digestion ?
(1) Conversion of complex substances into simpler form
(2) Absorption of monomers by the body
(3) Conversion of monomers into polymers
(4) Absorption of water and food

14. What is frenulum ?
(1) It is the fold by which tongue is attached to the floor of oral cavity.
(2) It is uvula is present on pharyngeal wall
(3) It is a tonsil like structure on the lateral walls of palate
(4) It is V-shaped furrow which divides the surfaces of tongue

(2) HISTOLOGY OF ALIMENTARY CANAL

Unilayered Epithelium in Stomach and Intestine

Mucosa: Epithelium	Multilayered Epithelium	Simple columnar glandular epithelium form Gastric Glands	Simple columnar glandular brush border Epithelium form Blunt-Villi	SCGBBE form Long-Pointed Villi
Mucosa: Lamina Propria of Reticular Fibrous CT			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 nerve plexus)			
Muscularis Layers: Longitudinal	Longitudinal	Longitudinal	Longitudinal	Longitudinal
Serosa- Made up of simple squamous epithelium or mesothelium	Areolar + WFCT called tunica adventitia	SSE + Fats + Lymph Tissues = Ommentum	Serosa	Serosa
	Oesophagus	Stomach	Duodenum	Jejunum and Ileum

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

(A) Serosa :

It is outer most layer of gut (it is called tunica adventitia in oesophagus) serosa is made up of a thin mesothelium (visceral peritoneum) with some connective tissue. Tunica adventitia is made up of white fibrous connective tissue and areolar connective tissue.

(B) Muscle layer :

It is formed by circular inner layer and longitudinal outer layer of smooth muscle. Thickest layer is found in stomach (maximum peristalsis) and thinnest layer in rectum (minimum peristalsis). An oblique muscle layer may be present in some regions.

(C) Sub mucosa :

It is loose connective tissue layer with blood vessels, lymph vessels and nerves.

(D) Mucosa :

It is the inner most layer of gut which contains the secretory and absorptive cells. Mucosal epithelium has goblet cells, secretes mucus that help in lubrication.

It is differentiated into 3 parts.

(i) Outer part :- Called mucosa muscularis.

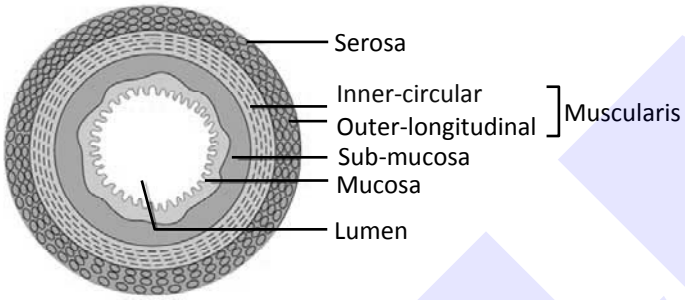
- It is made up of outer longitudinal and inner circular muscles.
- It has important role in exposing of surface area for the absorption
- They also provide support to the folds of alimentary canal.

(ii) Middle part :- It's called lamina propria it contains few modified lymphatic tissue which provides immunity ex. peyer's patches .

- It is made up of reticular and fibrous connective tissue.

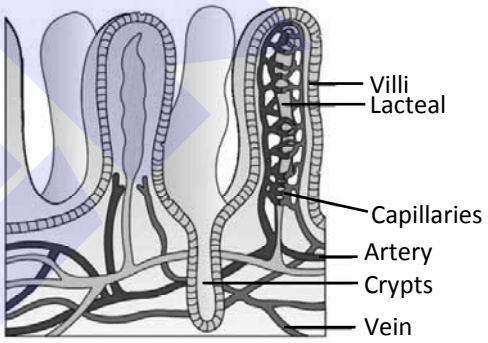
(iii) Innermost part :- Called mucosal epithelial layer.

- 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.
- This layer makes the lining of lumen of Alimentary canal.
- This layer makes the folds of alimentary canal.
- Folds of oesophagus are less developed. Invagination in mucosa of stomach develop as gland called gastric gland.
- There are conical shaped projections in small intestine called Villi. Villi are supplied with network of capillaries and a large lymph vessel called lacteal. Small slit like space is found at the base of villi. These spaces are called crypts of Lieberkuhn
- Maximum villi are found in Jejunum.
- All the four layers show modifications in different parts of alimentary canal.



Diagrammatic representation of transverse section of gut

NCERT XI, Page No. 260, Figure No. 16.4



A section of small intestinal mucosa showing villi

NCERT XI, Page No. 260, Figure No. 16.5

Brunner's Gland		Paneth Cells	
(1)	Present in submucosa of duodenum	(1)	Present in crypts of Lieberkuhn (Mucosa)
(2)	Multicellular gland	(2)	Unicellular glands
(3)	Secrete non enzymatic alkaline secretion of intestinal juice	(3)	Secretes lysozyme

Peyer's patches :-

- They are small lymph nodes which are found in the mucosa of small intestine (Jejunum and **Ileum more in number**).

  They are also called intestinal tonsils and provide immunity.

Nerve supply :-

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

- **Auerbach's Nerve plexus** (myentric plexus) this nerve plexus is found between longitudinal muscles and circular muscles, it control muscle contraction
- **Meissner's Nerve plexus** found between circular muscles and sub mucosa but in stomach it is found between oblique muscle & submucosa.

BEGINNER'S BOX — 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 secretion

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) Intestine (2) Stomach (3) Oesophagus (4) All of these

7. Out of four layers of alimentary canal, which one forms villi, (finger-like projection)?
(1) Serosa (2) Mucosa (3) Submucosa (4) Muscularis

8. Small finger-like projection, which produce numerous microscopic projections are supplied with a network of
(1) Blood capillaries and lacteal (2) Blood capillaries only
(3) Lacteal only (4) A large lymphoid vessel and valves

(3) DIGESTIVE GLANDS

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

(A) Salivary Glands :

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

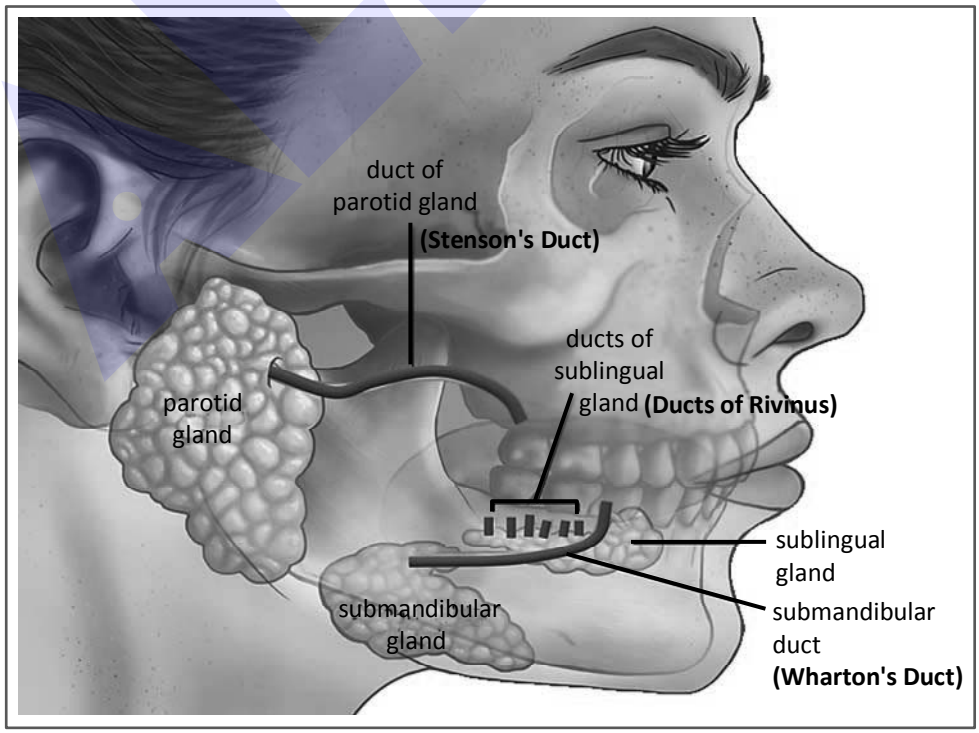
These glands are situated just outside the buccal cavity, secrete salivary juice into the buccal cavity.

In human 3 pairs of salivary glands are present.

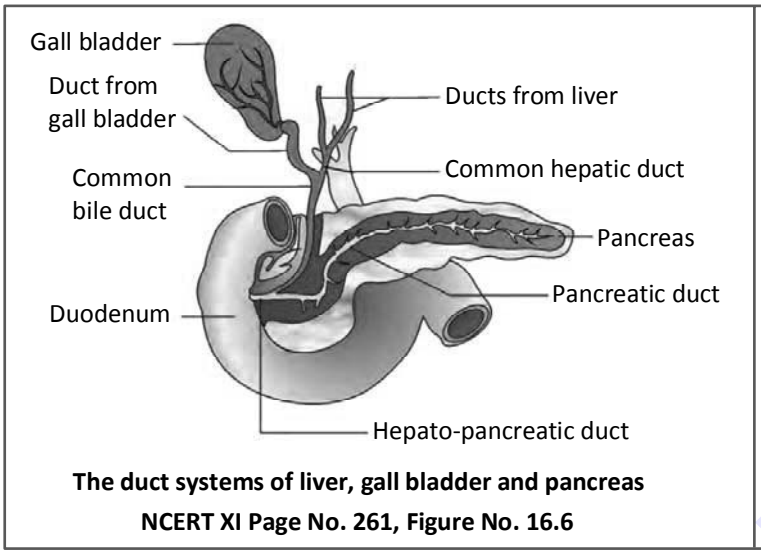
Salivary Glands				
		Parotid	Submaxillary	Sublingual
1.	Location	Below ear (cheek)	Jaw angle (lower jaw)	Below tongue
2.	Number	1 pair	1 pair	1 pair
3.	Duct	Stenson's duct	Wharton's duct (longest salivary duct)	Ducts of Rivinus or Bartholin's duct (smallest salivary duct)
4.	Secretion	Saliva + Enzymes	Saliva	Saliva
5.	Special point	Largest salivary gland and viral infection cause Mumps.	Secrete maximum amount of saliva	Smallest salivary gland

Composition of saliva :

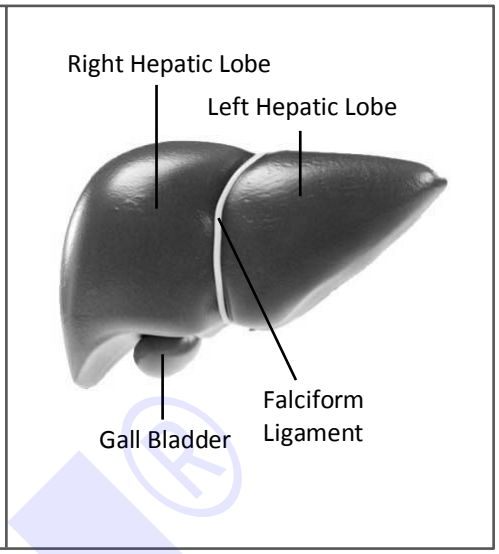
- Water-99.5%
- Mucus, starch -digesting **Ptyalin enzyme (Salivary amylase)**, lysozyme and thiocyanates and few ions like sodium, potassium, chloride, **IgA** antibody, **urea** and uric acid etc., are present.
- Ptyalin is secreted mainly by the parotid gland. Lysozyme and Thiocyanates mainly kill bacteria.
- Salivation is stimulated by cranial nerve VII & IX. Sympathetic nervous system decreases the secretion of saliva while parasympathetic nervous system increases the secretion of saliva.



(B) Liver :



The duct systems of liver, gall bladder and pancreas
NCERT XI Page No. 261, Figure No. 16.6



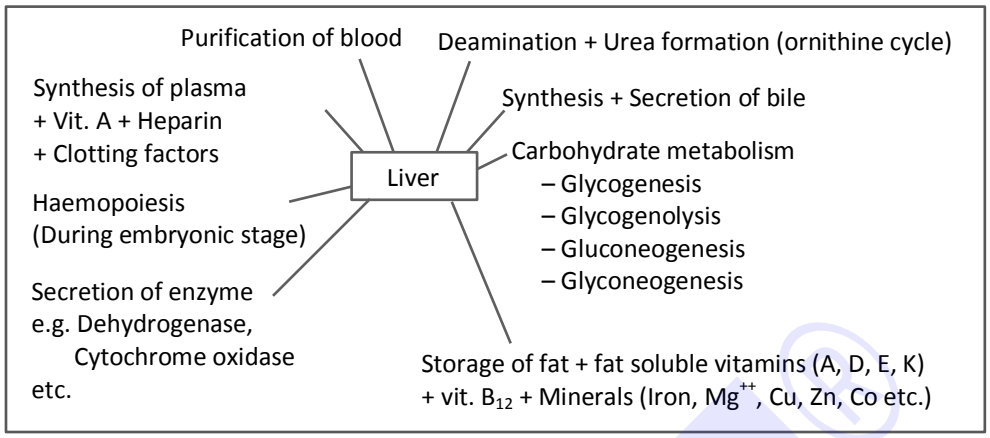
- Weight 1.2 to 1.5 kg, in human it is found in right side of abdominal cavity, below the diaphragm.
- The liver is the largest gland of body.
- It is made up of two lobes, left and right lobe. Left lobe is smaller than right lobe.
- Right and left liver lobes are separate from each other by the **falciform ligament** (Fibrous C.T.) which is made up of fold of peritoneum.
- Right and left hepatic duct arise from right and left liver lobe. Both these ducts combine to form a **Common Hepatic duct.**

  The **hepatic lobules** are the structural and functional units of liver containing hepatic cells arranged in the form of cords. Each lobule is covered by a thin connective tissue sheath called the Glisson's capsule. The bile secreted by the hepatic cells passes through the hepatic ducts and is stored and concentrated in a thin muscular sac called the gall bladder. The duct of gall bladder (cystic duct) along with the hepatic duct from the liver forms the common bile duct (ductus choledocus). The bile duct and the pancreatic duct open together into the duodenum as the common hepato-pancreatic duct which is guarded by a sphincter called the sphincter of Oddi.

- **Gall bladder** is situated below right lobe of liver.

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.



Bile-Juice

In the duodenum bile-juice is released. The Hepatocytes of the liver produce bile-juice and it is stored in the Gall- bladder. Bile-juice does not contain any digestive enzyme. Therefore it is not a true digestive juice (Pseudodigestive juice).

Composition of Bile-juice :- Bile-juice is a greenish (Biliverdin) yellow (Bilirubin) coloured alkaline fluid.

Composition of liver bile.

	Liver bile
pH	8.0
H_2O	98%

Constituents are bile salts, bile pigment, cholesterol, Phospholipid, Na^+, K^+ etc.

Bile-salts are of two types –

(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. It is necessary for making the medium basic, because the pancreatic-juice 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 function of these salts is the emulsification of fats, because pancreatic **Lipase** can act only on emulsified fats.

Function of bile juice :

- **Neutralization of HCl.** It neutralizes HCl of chyme (semifluid food found in the stomach).
- **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.
- **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.

(C) Pancreas :

- It is soft, lobulated and elongated organ, situated between the limbs of C-shaped duodenum.
- 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 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 opening located above the opening of major Pancreatic duct.
- Some group of endocrine cells are also found in between groups of acini called **islets of Langerhan's**. These islets secrete insulin (β-cell) & glucagon (α-cell) hormone. So this gland is exocrine as well as endocrine (Heterocrine). **Its 99% part is exocrine** while **1% part is endocrine**.
- 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 Duodenum and is controlled by **sphincter of Oddi** while bile duct is controlled by **sphincter of Boyden**

Pancreatic Juice :

- Pancreozymin stimulates the glandular cells of acini to secrete so pancreatic juice.
- 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 :

Water = 98%, pH = 7.5-8.3 (7.8), Salts = 2%

Pancreatic juice contains only inorganic-salts.

BEGINNER'S BOX — DIGESTIVE GLANDS

1. Islets of Langerhans _____ and are found in _____.

(1) Modified lymph glands, pancreas

(2) Ductless glands, pancreas

(3) Specialized area, pituitary

(4) Small tubules, kidney

2. Ptyalin is secreted by _____ and work in _____ medium.

(1) Stomach, acidic

(2) Salivary gland, slightly acidic

(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) Gama 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

10. In gut, serosa is outer most layer and made up of

(1) Endothelium (2) Smooth muscles

(3) Mesothelium (4) Dense connective tissue

03. DIGESTION OF FOOD

Digestion is accomplished by Mechanical digestion and Chemical digestion. Mechanical digestion takes place in mouth and small intestine.

(1) DIGESTION IN ORAL CAVITY

Buccal cavity perform two major functions, mastication of food and facilitation of swallowing.

Food entering through mouth is tasted in oral cavity and mixed with saliva. Tongue mixes the food with saliva. This food with saliva is called bolus. This saliva (pH 6.8 – 7.0) contains water (99.5%) and electrolytes (Na^+, K^+, Cl^-, HCO_3^-).

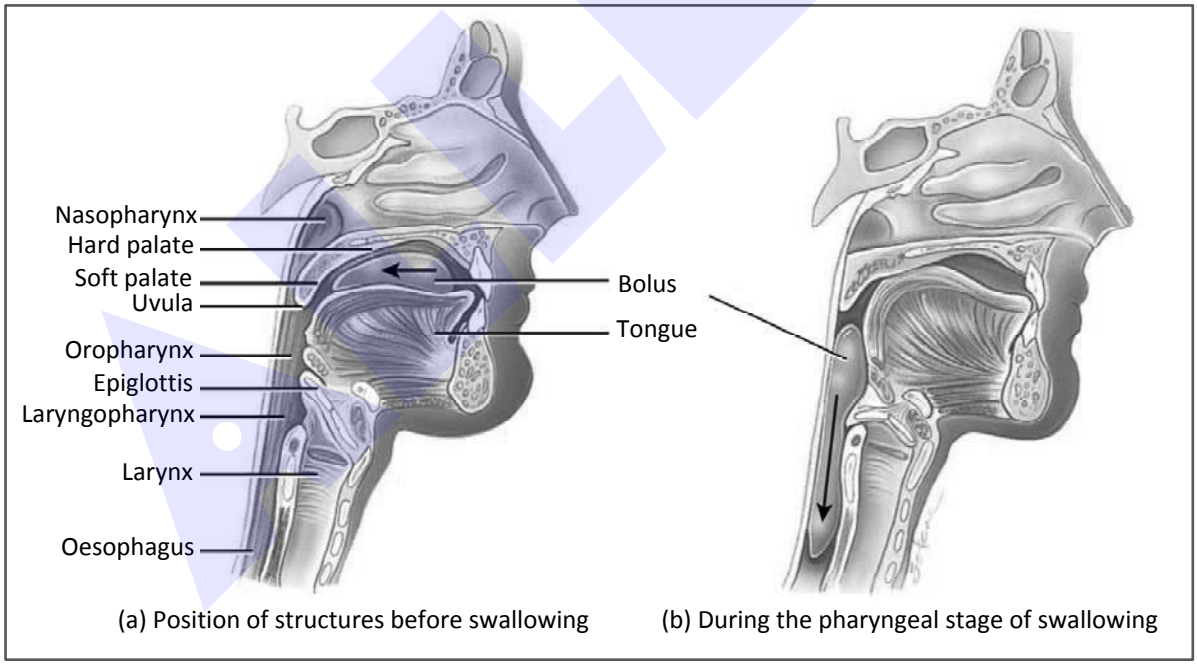
Mechanical digestion :–

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

Ptyalin (Salivary amylase) :-

- Starch $\xrightarrow[pH-6.8]{Ptyalin}$ Maltose

Ptyalin is found in human saliva, because human food is mainly made up of starch.
Ptyalin digest only ripe and cooked starch. 30% starch in buccal cavity is digested by ptyalin.
Ptyalin is absent in saliva of rabbit and carnivorous animals.

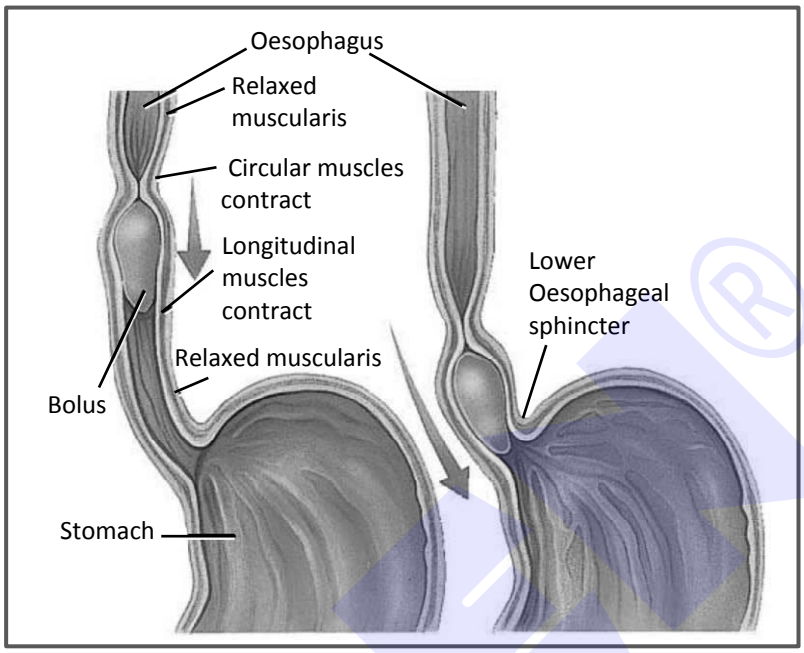


(a) Position of structures before swallowing (b) During the pharyngeal stage of swallowing

- 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.
- The tongue blocks the mouth, part of soft palate and uvula close off the internal nasal opening nose and larynx rises so that epiglottis closes off the trachea food move downward into the oesophagus. A travelling wave of constrictions called peristalsis pushes the Bolus (food) downward.

- Digestive enzymes are absent in Oesophagus but salivary amylase continue to function up to the last of oesophagus. The cardiac sphincter/Gastroesophageal sphincter opens allowing the passage of bolus to the stomach.

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



(2) DIGESTION IN STOMACH

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 proenzyme pepsinogen, on exposure to hydrochloric acid gets converted into the active enzyme pepsin, the proteolytic enzyme of the stomach. Pepsin converts proteins into proteoses and peptones (peptides). 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.

Food reaches in stomach and then G-cells secrete gastrin hormone, which stimulates secretion of gastric juice. Gastric juice secretion is controlled by neural hormonal method and by chemical substances.

Composition of Gastric juice :

Water = 99.5%

pH = 1.8 (very acidic)

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

Functions of HCl :

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

Pepsinogen $\xrightarrow{HCl}$ Pepsin.

Prorennin $\xrightarrow{HCl}$ Rennin.

(ii) It destroys the bacteria present in the food.

(iii) HCl stops the action of saliva on food. In stomach, the medium is highly acidic.

(iv) It dissolves the hard portions of the food and makes it soft.

- Pepsinogen and Prorennin are inactive enzymes.

Digestion by Rennin (Chymosin) :

- Rennin is secreted in the childhood stage of mammals. It converts milk into curd like substance (clot the milk) and then digests it. In adult stages, it is absent.
- 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. (clotting/coagulation/curdling of milk is done by HCl, pepsin and chymotrypsin in adult human).

Digestion by Pepsin-

Inactive pepsinogen on getting proper pH converts into active pepsin.

$$\text{Proteins} \xrightarrow[\text{pH–1.8}]{\text{Pepsin}} \text{Peptones + Proteoses [Peptides]}$$

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 & monoglyceride. 1% emulsified fat is present in the food.
- **Peristalsis** (Churning movement) 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 & semidigested in the stomach is called **chyme**.
- After short intervals, the pyloric orifice keeps on opening and closing so the chyme is fed into the intestine in instalments.

(3) DIGESTION OF FOOD IN SMALL INTESTINE

- In small intestine mechanical and chemical digestion occurs.
- The bile, pancreatic juice and intestinal juice are the secretions released into the small intestine.

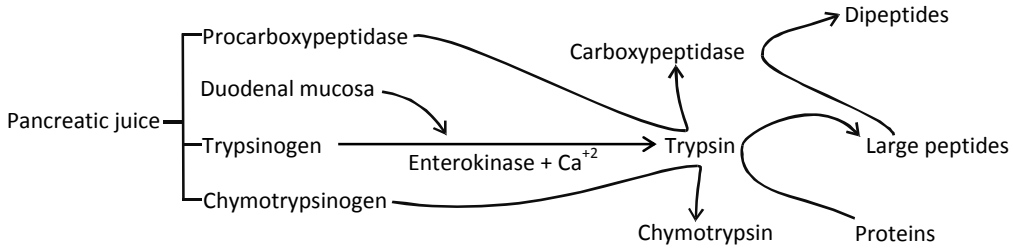
Mechanical Digestion : Food reaches to different parts of alimentary canal by peristalsis.

(A) Digestion in duodenum :

(i) **Pancreatic, α - Amylase :** Amylase dissociates starch into Maltose. Majority of starch breaks up into the duodenum.

$$\text{Starch} \xrightarrow[\text{(Amylopsin)}]{\text{Pancreatic amylase}} \text{Maltose}$$

(ii) Protein digestion in duodenum -



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

- **Pancreatic Lipase -** It converts triglyceride into monoglyceride and diglyceride.

(iv) DNase and RNase (Nucleases) **-** Digestion of DNA and RNA.

In duodenum, digestion of biomacromolecules takes place in the presence of bile juice and pancreatic juice, released through hepatopancreatic duct.

(B) Digestion in jejunum and ileum:

Final steps in digestion occur very close to the mucosal epithelial cells of intestine.

Some hormones stimulate the crypts of Leiberkuhn to secrete **Succus-entericus** or intestinal juice. The secretions of the brush border cells of the mucosa along the secretion of goblet intestinal juice. This succus entericus mainly contains water (99%) and digestive enzymes (<1%).

Succus-entericus mainly contains the following enzymes-

(i) Peptidase or Erepsin – Dipeptides $\xrightarrow{\text{Dipeptidases}}$ Amino acid.

It converts oligopeptides into amino-acids.

(ii) Disaccharidases

- Sucrose $\xrightarrow{\text{Sucrase (Invertase)}}$ Glucose + Fructose
- Maltose $\xrightarrow{\text{Maltase}}$ Glucose + Glucose
- Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose

(iii) Intestinal Lipase - This fat-digesting enzyme converts fats into **fatty-acids and glycerol**.

Di and monoglyceride $\xrightarrow{\text{Lipase}}$ Fatty acid + Glycerol

(iv) Nucleotidase and Nucleosidase - These act in the following way :-

(a) Nucleotides $\xrightarrow{\text{Nucleotidase}}$ Nucleosides + Phosphate

(b) Nucleosides $\xrightarrow{\text{Nucleosidase}}$ Pentose + Nitrogen base

The simple substance thus formed are absorbed in Jejunum and ileum region of small intestine.

The undigested and unabsorbed substance are passed in to large intestine.

(4) DIGESTION IN LARGE INTESTINE

- In herbivores, the symbiotic bacteria and protozoans present in the caecum help in digestion of cellulose into glucose. So the digestion of cellulose takes place in caecum by the process of **decomposition**. This **decomposition** process is very slow. So very less amount of cellulose is digested at a time in caecum.
- In the last part of the large intestine faeces is temporarily stored.

Maximum digestion of food – Duodenum.
While digestion of food complete in – Ileum.
Maximum absorption of food in – Jejunum.

BEGINNER'S BOX — DIGESTION OF FOOD

1. Bilirubin and biliverdin are formed in-
(1) Kidney (2) Liver (3) Salivary glands (4) Stomach

2. Lysozyme breakdown
(1) Protein (2) Sugar (3) Bacterium (4) Fat

3. Amylase enzyme acts on starch and convert it into-
(1) Maltose (2) Glucose (3) Fructose (4) Galactose

4. The food mixes thoroughly with acidic gastric juice of the ____ by the churning movement-
(1) Rectum (2) Duodenum (3) Stomach (4) Oesophagus

5. Which of the following enzyme is secreted by pancreas -
(1) Maltase (2) Trypsin (3) Rennin (4) Lactase

6. Proteolytic enzyme of stomach is -
(1) Trypsin (2) Pepsin
(3) Chymotrypsin (4) Carboxypeptidase

7. Gastric lipase is secreted by -
(1)Stomach (2) Pancreas (3) Liver (4) Ileum

8. Optimum pH for salivary amylase
(1) 1.8 (2) 7.8 (3) 6.8 (4) 3.4

9. Digestion of starch starts from the mouth, whereas ...A... is the site of digestion mainly for ...B... Choose the correct combination of options to complete the given statement.
(1) A-Stomach; B-Protein (2) A-Stomach; B-Starch
(3) A-Small intestine; B-Protein (4) A-Small intestine; B-Cellulose

10. Which enzyme works in highly acidic pH
(1) Pepsin (2) Lipase
(3) Erepsin (4) Amylopsin

11. Pepsin converts protein into -

(1) Proteoses and peptones (2) Dipeptides

(3) Amino acid (4) Both (2) & (3)

12. What is the important function of bile-

(1) Emulsification of fats

(2) Retention of excretory products

(3) Digestion by its enzymes

(4) Coordination of digestive activities

13. Disacchridases enzymes are-

(1) Lactase, Maltase, Sucrase

(2) Amylase, Lipase, Zymase

(3) Amylopsin, Steapsin, Ptyalin

(4) Trypsin, Erepsin, Pepsin

14. Bacteria entering with contaminated food are killed in stomach by -

(1) Pepsin (2) Renin

(3) Sodium bicarbonate (4) HCl

15. Chymotrypsin is-

(1) Proteolytic enzyme (2) Secreted by stomach

(3) An enzyme but not protein (4) Nucleic acid digesting enzyme

16. The bolus is conveyed into pharynx and then into oesophagus by

(1) Swallowing (2) Peristalsis

(3) Segmentation (4) Churning

17. Which of the following secretions gets mixed with the food (hydrolysed) in the small intestine?

(1) Bile, pancreatic juices and intestinal juices

(2) Pancreatic juices, intestinal juices and gastric juices.

(3) Gastric juices, intestinal juices and bile

(4) Bile, gastric juices and salivary juices

Regulation of digestion :

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.

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, pepsinogen 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). Secretion of pancreatic enzymes and bile juice
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.	Enterogasterone	Duodenum		Inhibit secretion of gastric glands

04. 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 monosaccharide 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 substances like glucose and 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, monosaccharaides like glucose, electrolytes like Na^+ are absorbed into the blood by this mechanism. Fatty acids and glycerol being insoluble, cannot be absorbed into the blood. They are first

incorporated into small droplets called micelles which move into the intestinal mucosa. They are re-formed into very small protein coated fat globules called the chylomicrons which are transported into the lymph vessels (lacteals) in the villi. These lymph vessels ultimately release the absorbed substances into the blood stream. Absorption of substances takes place in different parts of the alimentary canal, like mouth, stomach, small intestine and large intestine. However, maximum absorption occurs in the small intestine. A summary of absorption (sites of absorption and substances absorbed) is given in table.

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 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 of water, some minerals and drugs takes place.

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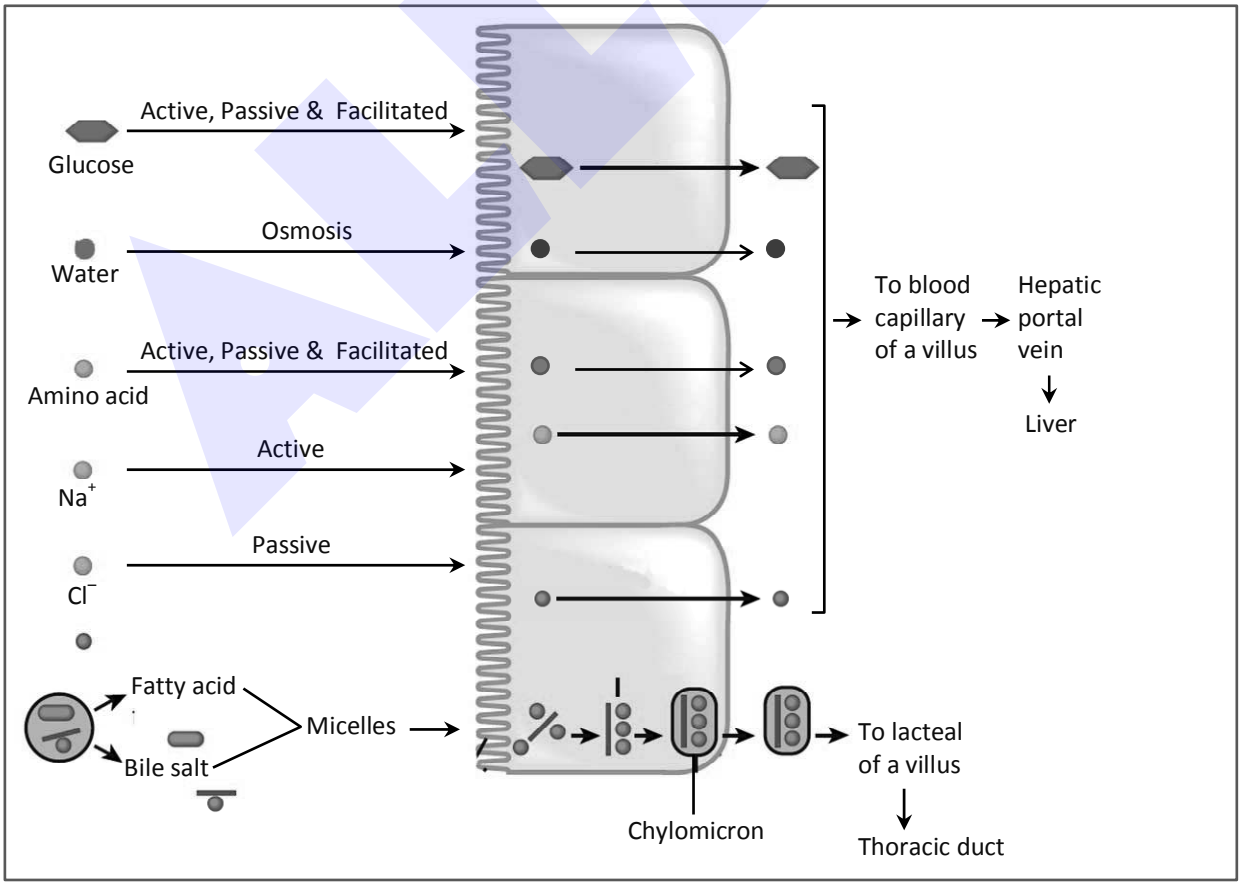
ABSORPTION IN DUODENUM : In duodenum iron and calcium ions are absorbed.

ABSORPTION IN JEJUNUM : Maximum absorption of food takes place in jejunum.

(Fats does not follow entero hepatic circulation)



(1) CALORIFIC VALUE :

The energy requirements of animals, and the energy content of food, are expressed in terms of measure of heat energy because heat is the ultimate form of all energies. This is often measured to as calorie (cal) or joule (J), which is the amount of heat energy required to raise the temperature of 1 g of water by 1 °C.

Since this value is tiny amount of energy, physiologists commonly use kilocalorie (kcal) or kilo joule (kJ). One kilo calorie is the amount of energy required to raise the temperature of 1 kg of water by 1 °C. Nutritionists, traditionally refer to kcal as the Calorie or Joule (always capitalised). The amount of heat liberated from complete combustion of 1 g food in a bomb calorimeter (a closed metal chamber filled with O_2) is its gross calorific or gross energy value. The actual amount of energy combustion of 1 g of food is the physiologic value of food. Gross calorific values of carbohydrates, proteins and fats are 4.1 kcal/g, 5.65 kcal/g and 9.45 kcal/g, respectively, whereas their physiologic values are 4.0 kcal/g, 4.0 kcal/g and 9.0 kcal/g, respectively.

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

(2) ASSIMILATION OF FOOD :

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

(a) Proteins and amino acids - Amino acids are not stored in body as they are highly reactive so converted into proteins which are building blocks of body.

(b) Carbohydrates

- Glucose is instant source of energy.
- Glucose $\longrightarrow$ Glycogen in liver (Glycogenesis) (Glycogen is stored food material)
- Whenever required, Glycogen $\longrightarrow$ Glucose (Glycogenolysis)
- Amino acids and fats $\longrightarrow$ Glucose in liver (Gluco neogenesis)
- Lactic acid formed in muscles $\longrightarrow$ Glycogen in liver by Glyconeogenesis

(c) Fats

- Stored in body, help in insulation and thermoregulation.
- Rich source of energy

(d) Minerals, water and vitamins plays vital role in many vital processes of body.

(3) EGESTION :

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.

Faecal matter is yellowish brown in colour due to the presence of pigments (Stercobilin, Urobilin). These two are formed due to degradation of bile pigments. Foul smell in excreta is due to the presence of CH_4, NH_3, indole (scatole) and H_2S.

BEGINNER'S BOX — ABSORPTION OF DIGESTED FOOD

1. Amino acids are absorbed in-

(1) Blood capillaries of villi (2) Wall of rectum

(3) Lacteals and blood capillaries of villi (4) Lacteals of villi

2. Absorption of digested food chiefly occurs in-

(1) Stomach (2) Colon (3) Small Intestine (4) Large Intestine

3. Excess amino acids are deaminated & converted into urea in -

(1) Kidneys (2) liver (3) Spleen (4) Pancreas

4. _____ is the instant source of energy.

(1) Glucose (2) Fructose (3) Galactose (4) Maltose

5. Fats are absorbed in _____

(1) Lacteals in stomach

(2) Lacteals in colon

(3) Lacteals in jejunum

(4) Blood capillaries in duodenum

6. Removal of waste from body in the form of undigested food is called

(1) Digestion (2) Absorption

(3) Assimilation (4) Egestion

7. Process of absorption of nutrients is carried out by

(1) Passive transport (2) Facilitated transport

(3) Active transport (4) All of the above

8. By which process, most of glucose and amino acids are absorbed in the small intestine?

(1) Active transport (2) Passive transport

(3) Osmosis (4) Selective absorption

9. What is the site of amino acids absorption in human's small intestine?

(1) Duodenum (2) Jejunum (3) Ileum (4) Both (2) and (3)

10. Absorption of fat occurs through the process of

(1) Active transport (2) Facilitated transport

(3) Osmosis (4) Simple diffusion

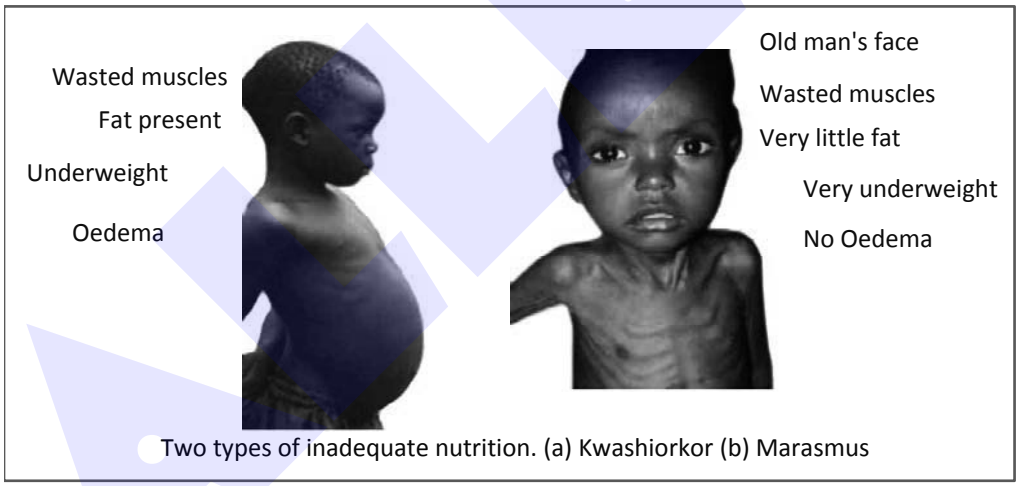
05. DISORDERS OF DIGESTIVE SYSTEM

(1) PROTEIN ENERGY MALNUTRITION

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 happened 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.



Two types of inadequate nutrition. (a) Kwashiorkor (b) Marasmus

	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.	Wasting 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 kwashiokar and marasmus physical growth and mental development is affected.

(2) DISORDERS OF ALIMENTARY CANAL

(A) The inflammation of the intestinal tract is the most common ailment due to bacterial or viral infections. The infections are also caused by the parasites of the intestine like tape worm, round worm, thread worm, hook worm, pin worm etc.

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

(C) ***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.

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

(E) ***Constipation :*** In constipation, the faeces are retained within the colon as the bowel movements occur irregularly.

(F) ***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.

(G) ***Fatty liver :*** 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.

(H) **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. This is termed as the Gall-stone (cholelithiasis).

BEGINNER'S BOX — DISORDERS

1. Vomit centre is located in :

(1) Medulla (2) Pons (3) Mid brain (4) Hypothalamus

2. Marasmus disease is caused due to :

(1) Protein deficiency (2) Obesity (3) Dwarfism (4) Deficiency of vitamins

3. Food is one of the basic requirement of all living organisms. The major component of our food are carbohydrates, proteins and fats. Food provides energy and organic materials for growth and repair of tissues. Deficiency of food will lead to protein energy malnutrition (PEM).

Which one of the following disease is characterized by PEM ?

(a) Marasmus with changes in hair (b) Kwashiorkar with wasted muscles

(c) Marasmus with old man's face (d) Marasmus with oedema.

(1) a, b (2) b, c (3) c, d (4) a, b, c

4. Balanced diet is diet rich in carbohydrates, mild in protein and low in fats with essential vitamins and minerals. Deficiency of proteins in diet of a children between age group of 1 to 3 will not lead of following symptoms.

(1) Wasted muscles (2) Oedema

(3) Dwarfism (4) Prominent ribs

5. Match the Column I & Column II correctly :

Column I		Column II	
A	Marasmus	(i)	Itching rashes
B	Kwashiorkar	(ii)	Increase chance of thrombosis
		(iii)	Old man's face
		(iv)	Oedema

(1) A - (iii), B - (ii) (2) A - (iii), B - (iv) (3) A - (iii), B - (i) (4) A - (i), B - (iv)

6. The abnormal frequent movement of the bowl and increased liquidity of the faeces is called

(1) Vomiting (2) Indigestion (3) Constipation (4) Diarrhoea

7. The inflammation of intestinal tract is due to the infection of which microorganism?

(1) Bacteria (2) Virus (3) Mycoplasma (4) Both (1) and (2)

(3) VITAMINS

Earliest extracted vitamin = Vitamin - B_1

Vitamins are following types –

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

Vitamin	Common name	Deficiency disease
A	Retinol	Nightblindness (Nyctalopia) Xeropthalmia, Dermatitis
B_1	Thiamine	Beri-beri/Polyneuritis/Cardio vascular atrophy
B_2	Riboflavin vitamin-G or Yellow Enzyme	Cheilosis, Glossitis, Keratitis
B_3	Niacin	Pellagra
B_9	Folic acid/Folate	Macrocytic anaemia
B_{12}	Cyano - Cobalamine	Pernicious anaemia
C	Ascorbic Acid	Scurvy, Anaemia, Joint pain, Collagen formation
D	Calciferol	Rickets in Children and Osteomalacia in Adults
E	Tocopherol/Antisterility/ Beauty Vitamin	Macrocytic Anaemia, Muscular dystrophy
K	Menadione/Phylloquinone	Severe bleeding

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
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
Dipeptidase	Small intestine	Dipeptides	Amino acids
Disaccharidases	Small intestine	Disaccharides	Monosaccharides
Nucleotidase	Small intestine	Nucleotides	Nucleosides & phosphoric acid
Nucleosidases	Small intestine	Nucleosides	Sugars, purines pyrimidines
Lipase	Small intestine	Diglycerides	Glycerol, fatty acids

BEGINNER'S BOX — ANSWERS KEY

ANATOMY OF ALIMENTARY CANAL

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ans.	**1**	**1**	**2**	**4**	**1**	**3**	**1**	**1**	**1**	**3**	**2**	**3**	**1**	**1**

HISTOLOGY OF ALIMENTARY CANAL

Que.	1	2	3	4	5	6	7	8
Ans.	**2**	**4**	**3**	**4**	**2**	**1**	**2**	**1**

DIGESTIVE GLANDS

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	**2**	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**1**	**3**

DIGESTION OF FOOD

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans.	**2**	**3**	**1**	**3**	**2**	**2**	**1**	**3**	**1**	**1**	**1**	**1**	**1**	**4**	**1**
Que.	16	17													
Ans.	**1**	**1**													

ABSORPTION OF DIGESTED FOOD

Que.	1	2	3	4	5	6	7	8	9	10
Ans.	**1**	**3**	**2**	**1**	**3**	**4**	**4**	**1**	**4**	**4**

DISORDERS

Que.	1	2	3	4	5	6	7
Ans.	**1**	**1**	**2**	**4**	**2**	**4**	**4**