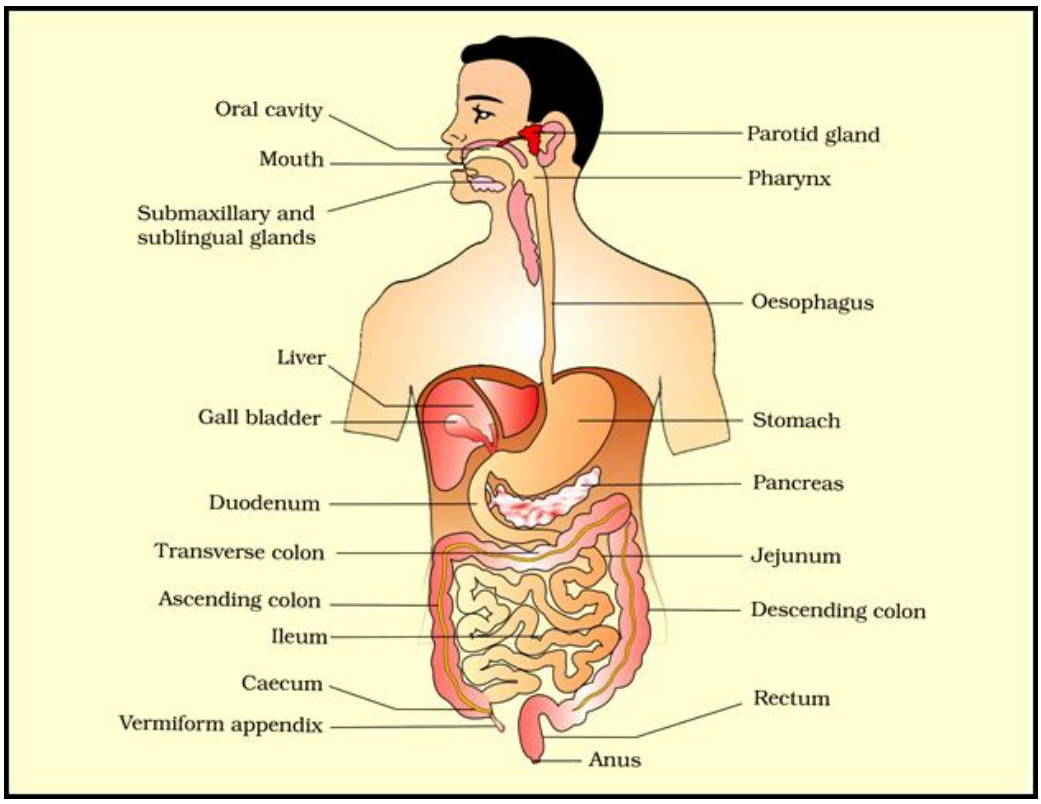
DIGESTION AND ABSORPTION

✉ 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 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 substance 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 mechanical and biochemical methods.

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



Origin

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

Digestive system of huamn

Alimentary canal
Buccal cavity
Oesophagus
Stomach
Intestine

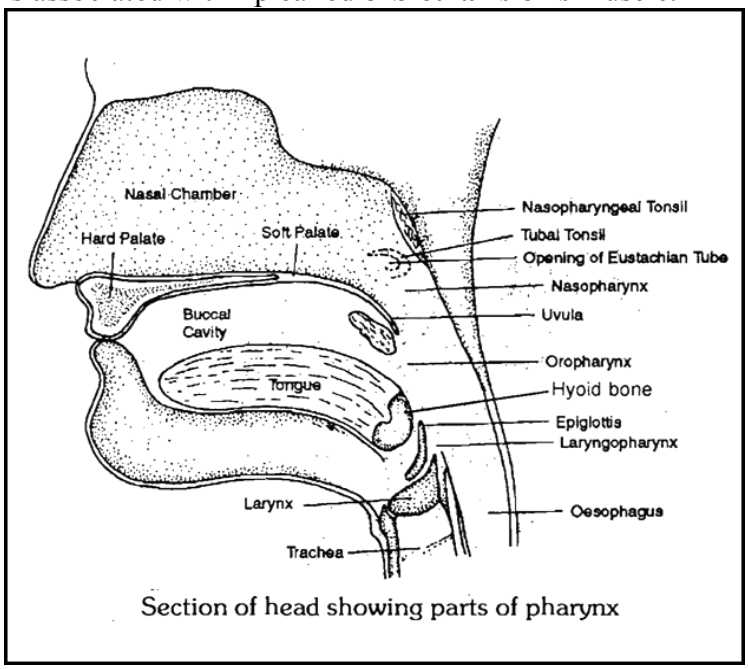
Small Intestine
Duodenum
Jejunum
Ileum

Large Intestine
Caecum
Colon
Rectum

Accessory digestive glands
Salivary glands
Liver
Gall bladder
Pancreas

(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

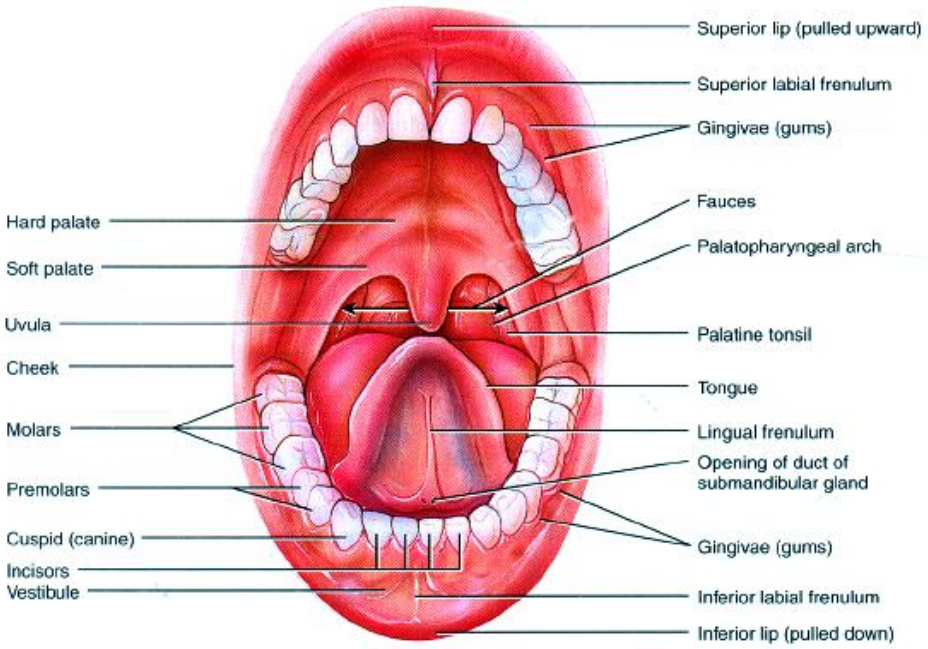
Mouth opens into buccopharyngeal cavity, this cavity is divided into two parts.

(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.

PALETE

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 of 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.

- Soft palate is situated in the pharynx and 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.

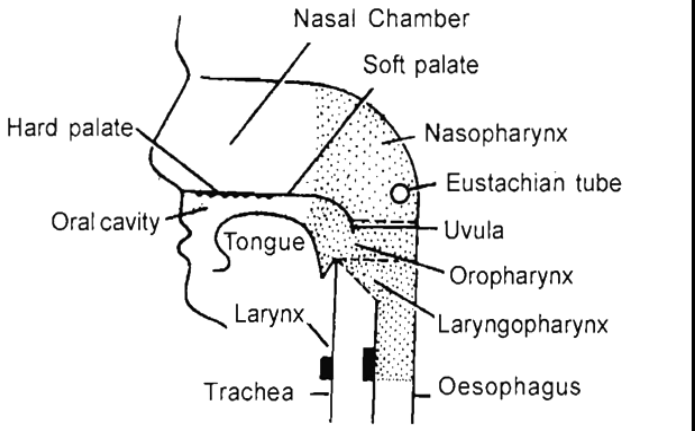
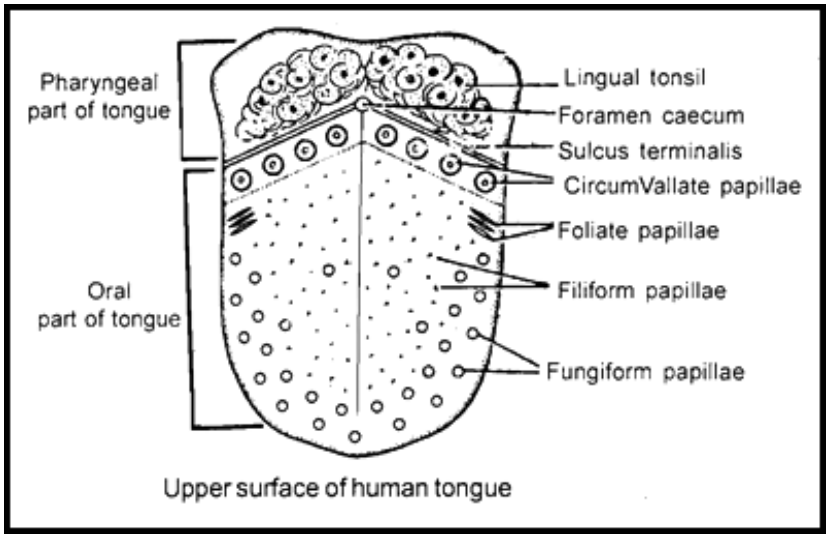


Diagram showing parts of pharynx

TONGUE



Upper surface of human tongue

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.**

(iv) Circumvallate papillae –
It is largest and least existed papillae (8 to 12), they are large spherical shape papillae which are found near to 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.

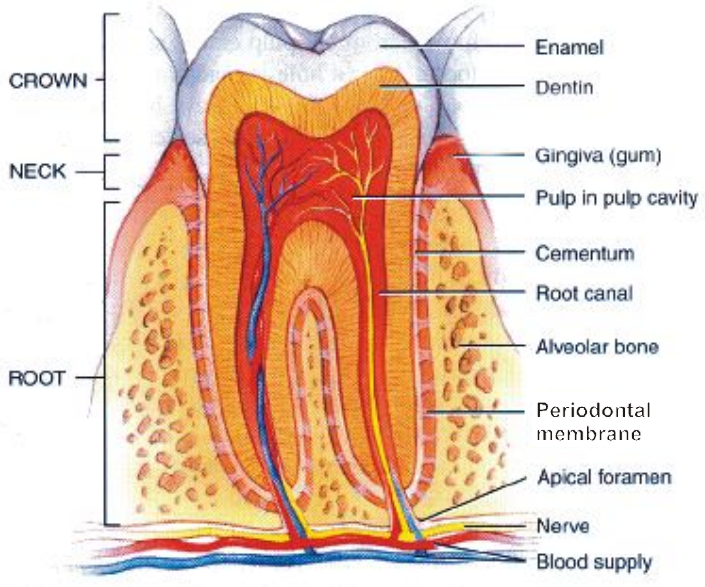
Crown- It is the outer part of the tooth, exposed **outside gums.**

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. 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, 1st and 2nd molars.**

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

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

Dental formula :-

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

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

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

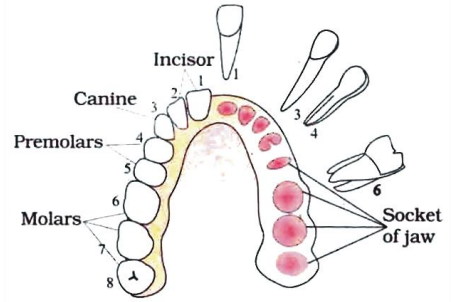
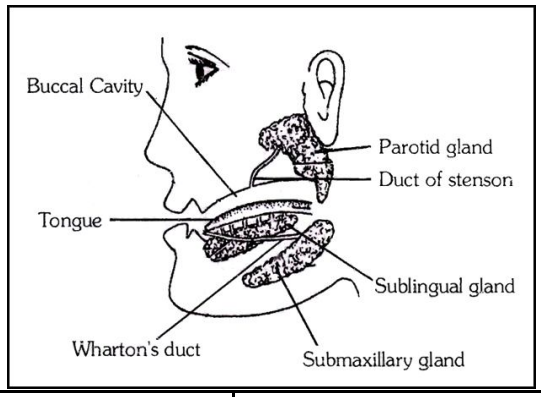


Fig. Arrangement of different types of teeth in the jaws on one side and the sockets on the other side

SALIVARY GLANDS

In human, these pair of salivary glands are present. These are situated outside the buccal cavity.



	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)	Duct of Rivinus (Shortest salivary duct)
Opening of Ducts	In vestibule of upper jaw	Behind lower incisors	In buccopharyngeal cavity on ventral side of tongue
Salive	25%	70% (Maximum)	5% (minimum)
Nerve	IX^{th}	VII^{th}	VII^{th}

Saliva :- Secretion of salivary glands.

Daily secretion = 1500 ml. (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	Long-Pointed Villi, Paneth cells
Mucosa: Lamina Propria Areolar Connective tissue			Crypts of Lieberkuhn	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 oblique** 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 part :- (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.

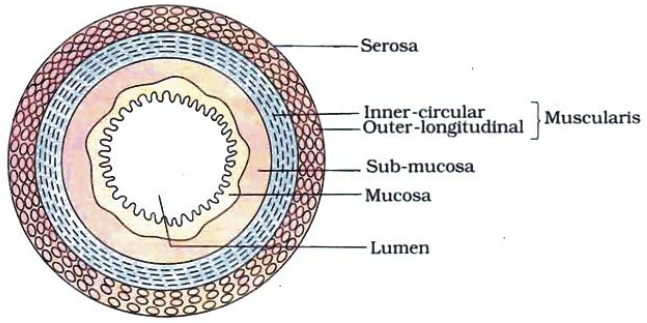


Fig. Diagrammatic representation of transverse section of gut

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

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

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

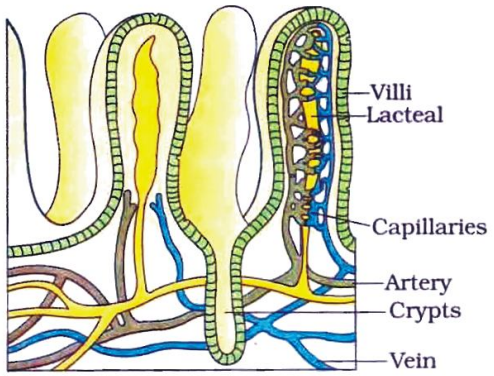


Fig. A section of small intestinal mucosa showing villi

✉ 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)

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 HCl.

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 (= myentric plexus) this nerve plexus is found between longitudinal muscles 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.

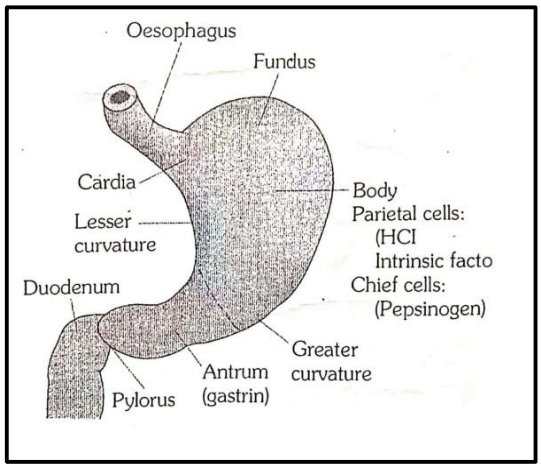
  The stomach contains following parts –

  Cardia, Fundus, Body, Pylorus

  It has two orifices (opening)

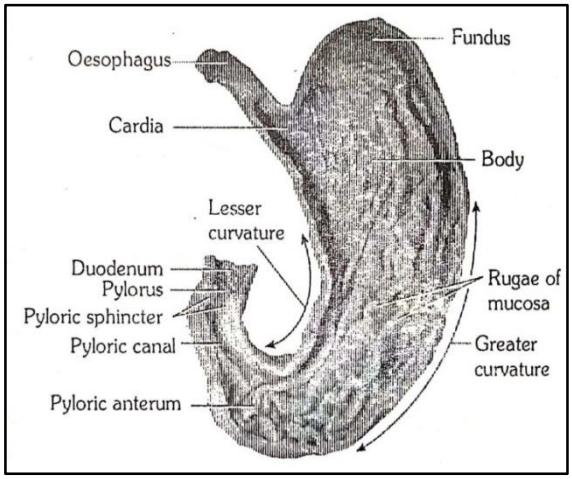
  (i) **Cardiac orifice** is joined by the lower end of the oesophagus.

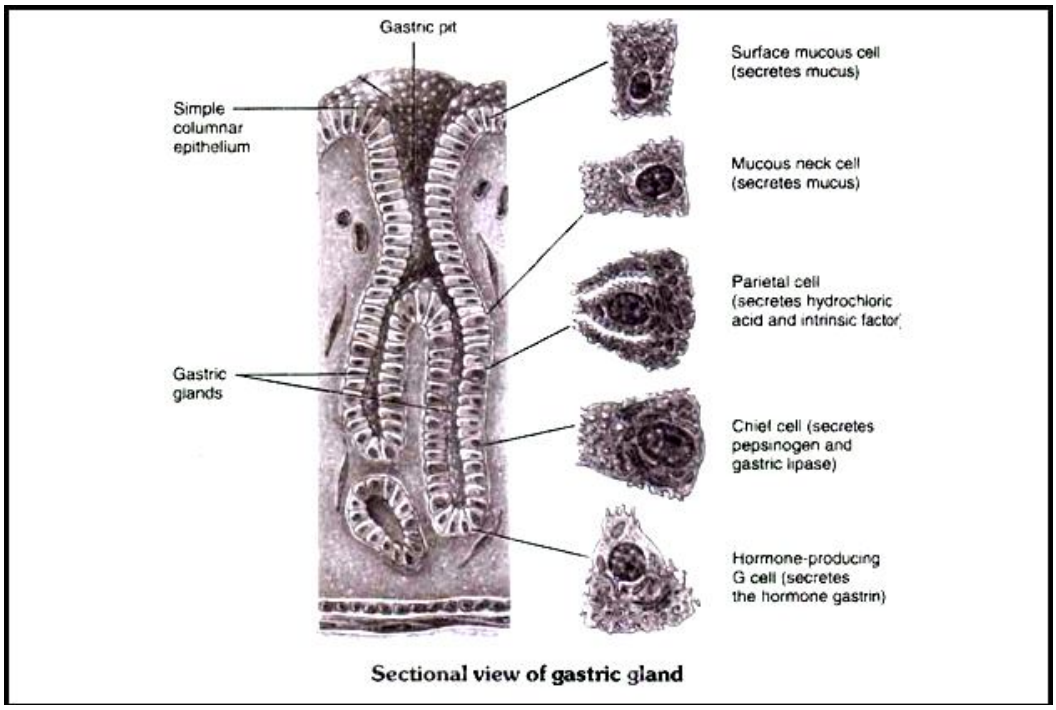
  (ii) **Pyloric orifice** opens into the duodenum.



- Stomach is covered by layer of peritoneum. Fat tissues and lymph tissue deposits on the peritoneum. Such type of peritoneum are called **Omentum**. Greater curvature attached with more deposition of lymph tissue 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 mixed thoroughly with the acidic gastric juice of the stomach by the churning movements of its muscular wall and is called the **chyme**. The mucus and bicarbonates present in the gastric juice play an important role in lubrication and protection of the mucosal epithelium from excoriation by the highly concentrated hydrochloric acid. HCl provides the acidic pH **(pH 1.8)** optimal for pepsin.





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.**

Function of HCl –

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

   $$\text{Pepsinogen} \xrightarrow{HCl} \text{Pepsin.}$$

   $$\text{Prorennin} \xrightarrow{HCl} \text{Rennin.}$$

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

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

(4) Enteroendocrine cells or **argentaffin cells** are usually present in the basal parts of the gastric glands, which is differentiated in three cells - these cells are **D-cells, Enterochromaffim 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%

HCl = 0.2 - 0.3 %

pH = 1.5 to 2.5 (very acidic)

Rest is mucus, water and gastric enzyme (Pepsinogen, Prorennin, Gastric lipase etc.)

INTESTINE

It is divided into two part

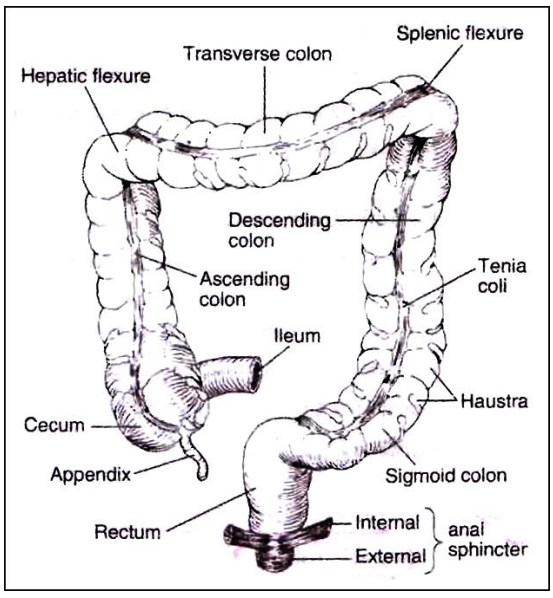
(i) Small intestine (ii) Large intestine

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 on the **Ileo-caecal junction**. The Ileocaecal opening is guarded by **Ileocaecal valve**. Caecum is a small blind sac.
- About 2 cm below the ileocaecal orifice, a worm like structure arises from the caecum called as **vermiform appendix**. Its length varies from 2 to 20 cm. It is a vestigeal organ. (Caecum is well 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 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 vasoconstrictor and stimulates smooth mucles. Histamine dialates the walls of blood vessels. Gastrin stimulates the gastric glands to release the gastric juice.

6. Least perastalsis occurs in Rectum.

PRACTICE–1

1. Dental formula of adult man 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) taenia

3. pH of stomach in human is about –

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

4. Number of teeth which are monophydont in man is –

(1) 4 (2) 22 (3) 8 (4) 11

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) Neutrilization of HCl by alkaline gastic juice.
(3) HCl being to dilute
(4) Epithelium being resistant to HCl

6. The structure which prevents entry of food into wind pipe 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) Canines and Molars

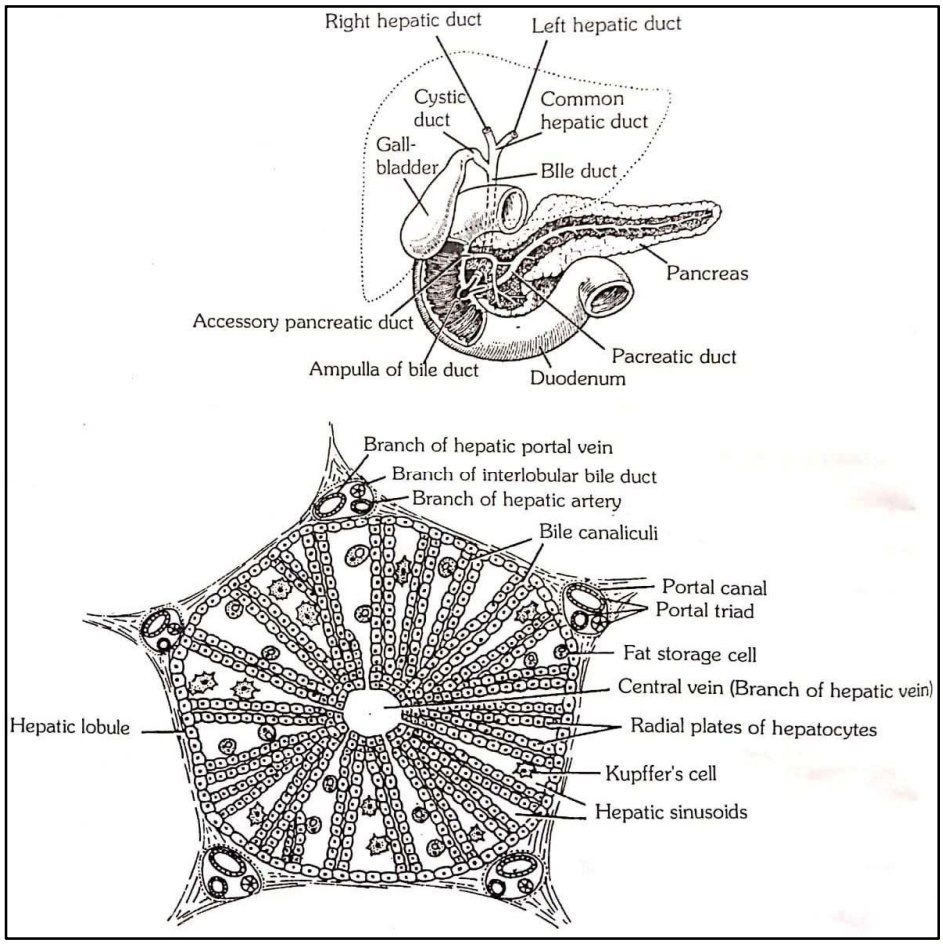
13. Presence of water amount in enamel is –
(1) 90-92% (2) 75-85% (3) 40-50% (4) ≈ 3%

ANSWER KEY	1	2	3	4	5	6	7	8	9	10	11	12	13
	1	1	2	4	1	3	1	1	1	3	2	3	4

ACCESSORY DIGESTIVE GLANDS

LIVER

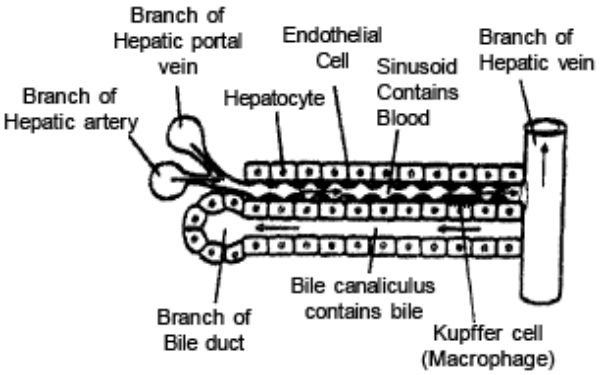
- It develops from **endoderm**. (Weight 1.2 to 1.5 kg). In human it is found in right side of abdominal cavity, below the diaphragm.
- The liver is the largest gland of body.
- It is made up of left and right lobe. Left lobe is smaller than right lobe. **Right** lobe forms 5/6 of the liver and **left** lobe forms **1/6** of liver.
- Right and left liver lobe are separate from each other by the **falciform ligament**, (Fibrous C.T.) which is made up of fold of peritoneum.



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 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.**

HEPETIC LOBULE



- 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 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 & 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 $\rightarrow NH_3$)

   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 protein 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 salt –

(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 salt is the emulsification of fats because pancreatic lipase can act only in emulsified fats.

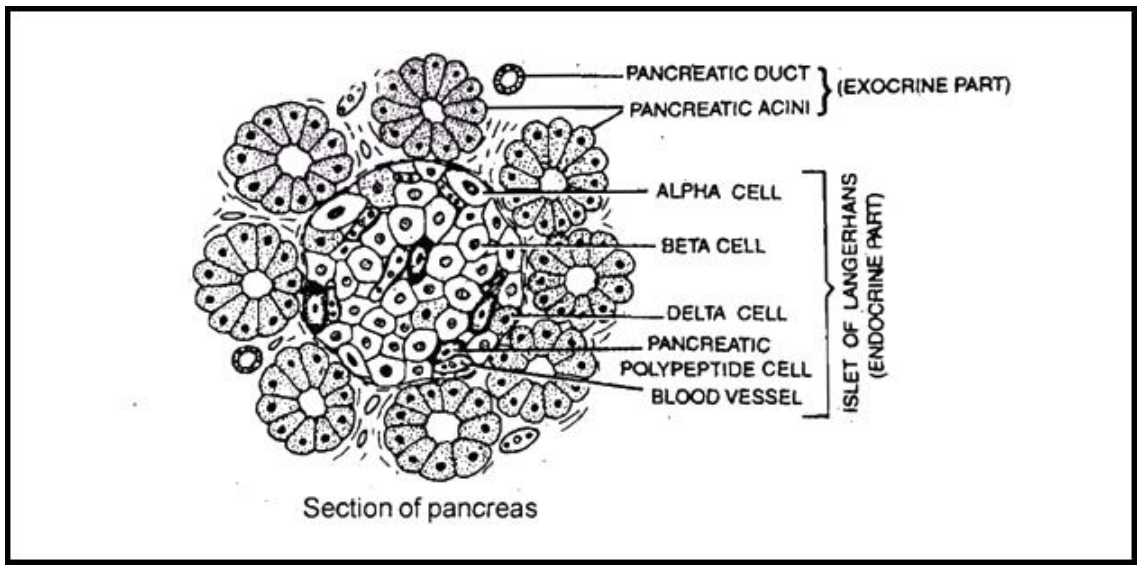
Bile salts also help in the absorption of fats and fat-soluble vitamins (A,D,E,K) bile salt combine with fats, cholesterol, phospholipid (lecithin) and these vitamins to form compounds called **micelles.**

FUNCTION OF BILE JUICE

- **Neutralization of HCl.**
- **Emulsificaion. 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).

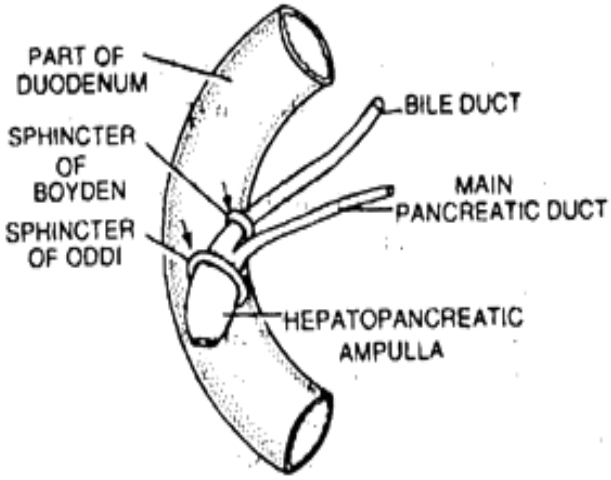
PANCREAS



- 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 enzyme of pancreatic juice.



- Each acini opens into pancreatic ductule. Many pancreatic ductule combine to form main pancreatic duct **(duct of Wirsung)**. The main pancreatic duct is join with the common bile duct to form the hepatopancreatic ampulla which opens into duodenum. The opens us 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 opening 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 called **Islets of Langerhan's**. These islets secrete glucagon, insulin, somatostatin and pancreatic polypeptide hormone respectively.

PANCREATIC JUICE

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

Composition of pancreatic Juice -

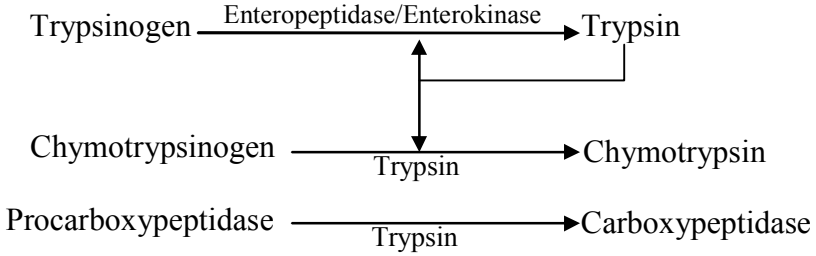
Daily secretion in human = 1 - 1.5 litre/day

Water = 98% Salt 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:



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.

Nucleaseases (= DNase and RNase) - Digestion of DNA and RNA respectively into nucleotides.

PRACTICE –2

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 enzyme 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

ANSWER KEY	1	2	3	4	5	6	7
	2	4	3	4	2	1	1

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 $\xrightarrow{\text{Ptyalin}}$ 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 (digestion 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 human).

Digestion by pepsin

Inactive pepsinogen on getting proper pH converts into active pepsin.

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

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

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

DIGESTION OF FOOD IN SMALL INTESTINE-

- In small intestine mechanical and chemical digestion occurs.

Mechanical Digestion :

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

Chemical digestion :

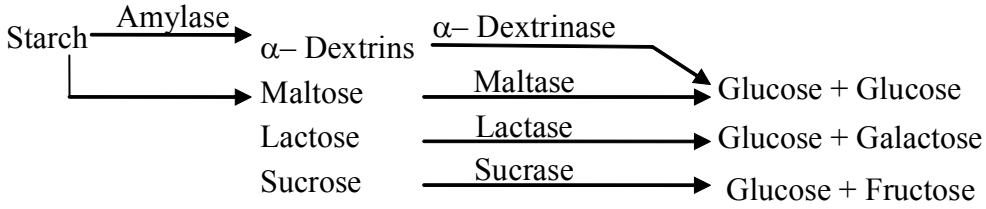
When food leaves the stomach through its pyloric end and enters the duodenum it is called chyme (acidic).

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 as help in this.

Succus-entericus mainly contains the following enzymes-

Glycosidases



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

Peptides - 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:-

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

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

DIGESTION IN LARGE INTESTINE :-

No significant digestive activity occurs in the large intestine. The function 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) Escherichia coli (bacterium) lives in the colon which feeds on undigested matter. This bacterium, in turn produces Vitamin –B_{12}, B_1, B_2 and K that are absorbed by the wall of the colon.

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

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-acids
Peptidase	Small intestine	Oligopeptides	Amino acids
Disaccharidases	Small intestine	Disaccharides	Monosaccharides
Nucleotidase	Small intestine	Nucleotides	Nucleosidases phosphoric acid
Nucleosidases	Small intestine	Nucleosides	Sugars, purines pyrimidines
Lipase	Small intestine	Triglycerides	Monoglycerides, glycerol, fatty acids

ROLE OF SOME MAJOR GASTROINTESTINAL HORMONES

	Hormone	Source of Secretion	Stimulus	Target/Action
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 mobility.
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 biocarbonate from pancreas inhibition of gastric mobility. Its 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 chime	Stimulate Brunner's gland to secrete alkaline mucus.

6.	Enterocrinin	Duodenum	...	Stimulated 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 if stomach
9.	Enterogasterone	Duodenum	...	Inhibit secretion of gastric glands.

ABSORPTION OF DIGESTED FOOD

Absorption in 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**.

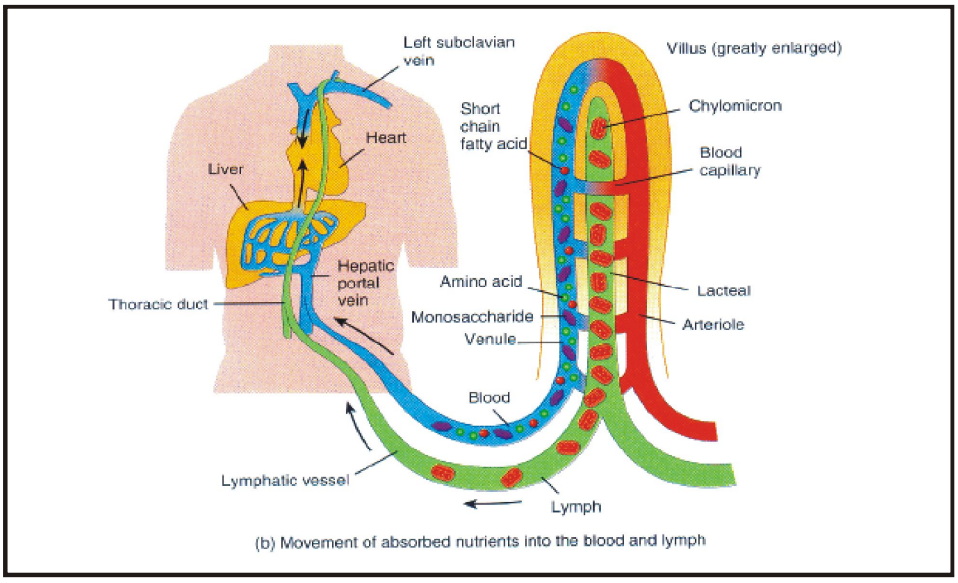
Absorption of Carbohydrate

- 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 were they are hydrolyzed to amino acids by dipeptidases and tripeptidases to get absorbed via portal veins.

Absorption of fat –

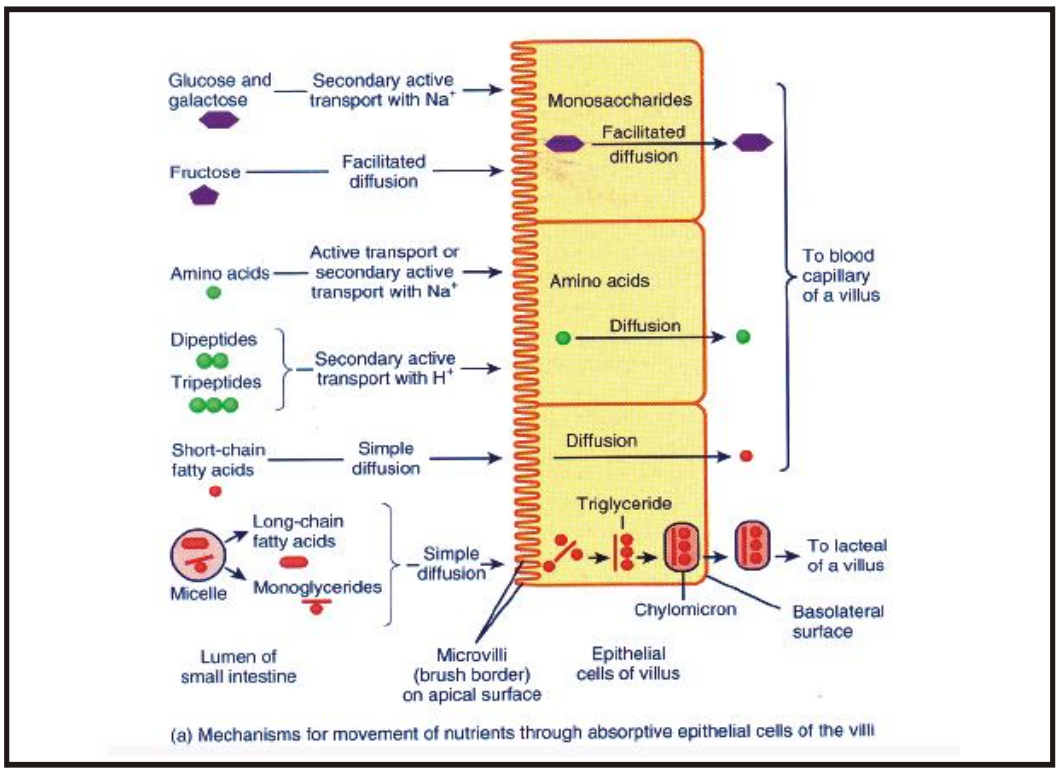


(b) Movement of absorbed nutrients into the blood and lymph

- 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 **chylomicron** (150 μm, white). Chylomicron enters the lacteal.
- Fat soluble vitamins are absorbed along with dietary fat whereas water soluble vitamins are absorbed by passive diffusion. Vit. 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 sugars, and alcohol etc. takes place.	Principal organ for absorption of nutrients. The digestion is completed here and the final product 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 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 **defaection**.
- The digestive wastes, solidified into coherent faces 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.

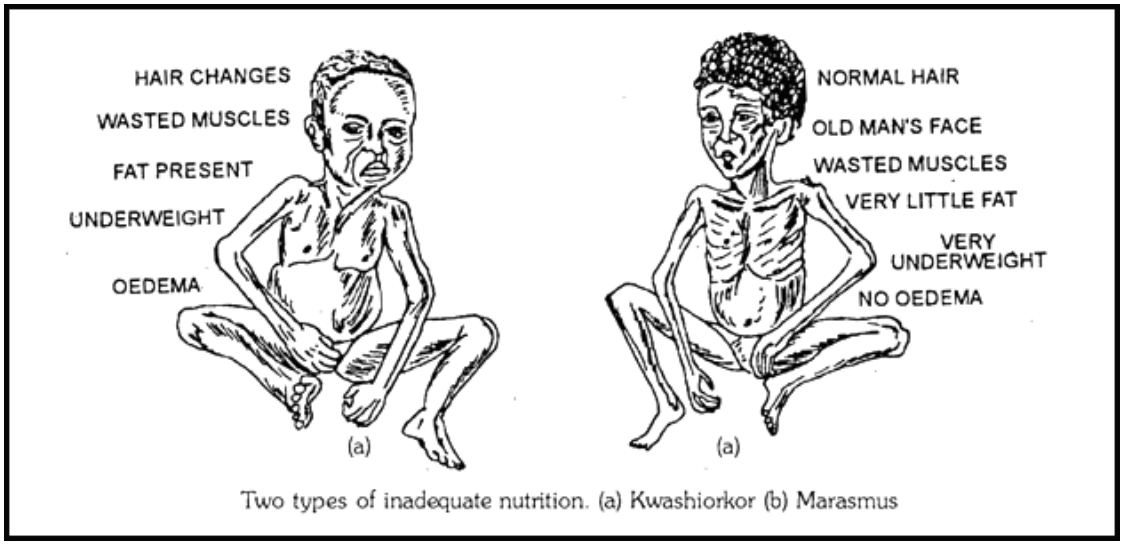
Vomiting : It is the ejection of stomach contents through the mouth. This reflex action is controlled by the vomit centre in the medulla. A feeling of nausea precedes vomiting.

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



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

Protein Energy Malnutrition (PEM)

No.	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 Kwashiorkar and Marasmus Physical growth and mental development is affected

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 server 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 condiderably. 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

Vitamin is organic molecule and essential micronutrient that an organism needs in small quantities for the proper functioning of its metabolism and growth.

Vitamin term is given by **Casimir funk**. (Vita = life + amine)

Earliest extacted vitamin = Vitamin - B_1. (B_1 from unpolished rice–1912)

Earliest known vitamin = vitamin 'C' (James Lind – scottish naval surgeon – 1747)

Vitamins are imporant to maintain health, but cannot synthesize in the body.

Vitamins were discovered by "Lunin".

Vitamins are micronutrients, biological regulators and metabolic regulators (Vitamin theory)

VITAMINS

Fat Soluble vitamin	Water Soluble vitamin
Ex:- A, D, E, K	Ex:- B – Complex C – Vitamin

Vitamin	Common name	Source	Deficeincy disease	Symptoms	Functions
B_1	**Thiamine**	Wheat, Gram, Peanuts, Yeast, Beans	**Beri-beri/** Polyneuritis/ Cardio vascular atrophy	Loss of appetite, Fatigue, Muscle Atrophy, Paralysis, Cardiomegaly	From coenzymes in carbohydrate metabolism and help in pentose metabolism,
B_2	**Riboflavin** vitamin-G or Yellow Enzyme	Yeast, Liver Milk, Cheese, Leafy Vegtables and **Intestinal Bacteria**	**Cheilosis,** Glossitis, Keratitis	Eye Inflammation and Lip sores	Part of coenzymes (FMN and FAD) in ETC
B_3	**Niacin**/Vitamin 4-D/PP-Factor	Yeast Gram, Peanuts and Meat	**Pellagera,** 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 functioing 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 for nerve formation, Formation of actylcholine, For normal adrenal gland
B_6	**Pyridoxine**	Meat Milk, Wheat, Liver, Banana	Nausea and Vomiting	Skin lesions, CNS disorders and convoulsions	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 pyramidine) synthesis and protein synthesis, Erythropoiesis, Cell division in bone marrow
B_{12}	**Cyano – Cabalamine**	Liver and Eggs	**Pernicious anaemia /Megaliblastic anemia**	Large and immature RBC nucleated RBC's without hemoglobin	Coenzymes for nucleic acid synthesis
A	**Retinol**	Yellow and Green Vegatables, Fruits, Milk and Butter	**Nightblindness** (Nyctalopia) **Xeropthalmia** Dermatitis	Keratinisation of skin, respiratory and urinogenital tract	Growth Prevent keratinization of epithelia
C	**Ascorbic Acid**	Amla, Citrus fruits, Tomatoes	**Scurvy,** Anaemia, Joint pain	**Bleeding Gums**, Loose teeth, Aneamia and Painfull Swollen joints	Play an imporatant role in **collagen 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 Ostomalacia in Adults	Weak and Soft bones distorted Skeleton and Poor muscular development	Facilitates Ca and P absorption by intestine
E	**Tocopherol**/ Antisterlity/ Beauty Vitamin	Leafy Vegatables, Cereals and Vegatable oils	Macrocytic Anaemia, **Muscular dystrophy**	Destruction of RBC	**Antioxidant** and plays an important role in ETS, **Selenium metabolism**, formation of RNA, DNA and RBC
H	**Biotin**/ Vitamin-B_7/ Antiavidin	Vegatables and Fresh Fruits, Liver, Milk, Eggs	**Dermatitis**	Scaly skin Muscle pain and weakness	Coenzyme in fatty acid synthesis and change of pyruvate into **OAA**
K	**Menadione/ Phylloquinone**	Leafy Vegatables, Soyabean oil and **Intestinial Bacteria**	**Severe bleeding**	Slow or delayed blood clotting	Synthesis of prothrombin for normal blood clotting, Present in **intestinal bacteria**

ADDITIONAL POINT

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 alga) contains B_{12}.

3. Anticancer vitamins-A, B_{17}, 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	Deformation 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 production	Normal acitvity of insulin, carbohydrate and lipid metabolism
Selenium	Male infertility, prostate cancer, **liver necrosis** and **muscular dystrophy**	Antioxidant, Protection of male sperm and its motility hence it requires for male fertility. Formation of thyroid hormone
Flourine	Excess amount creates **mottling of teeth and deformity** in bones (Hunch back)	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 flourine, zinc, copper, manganese, cobalt, selenium, chromium and molybedenun.		

PRACTICE–3

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, 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) Lysosome (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

ANSWER KEY	1	2	3	4	5	6	7	8	9
	2	2	2	3	2	3	2	2	1

EXERCISE–I

ALIMENTARY CANAL (MOUTH OF ANUS)

1. Parietal cells of mucosa in stomach is secrets :

(1) Mucin (2) Pepsin

(3) HCl (4) All of the above

2. Enamel of teeth is secreted by :-

(1) Ameloblast (2) Odontoblast

(3) Osteoblast (4) Osteoclast

3. Dental formula of adolescent human being before seventeen year:-

(1) $\frac{2122}{2122}$ (2) $\frac{2123}{2123}$

(3) $\frac{2102}{2102}$ (4) $\frac{2023}{1023}$

4. Which cells of mucous layer of stomach secrete pepsinogen

(1) Chief cell (2) Goblet cell

(3) Parietal cell (4) Oxyntic cell

5. Innermost layer of mucosa is made up of columnar epithelium except :–

(1) Oesophagus (2) Duodenum

(3) Intestine (4) Stomach

6. How many teeth in man grows twice in life :

(1) 32 (2) 28 (3) 20 (4) 12

7. In human teeth, which help in cutting

(1) Canine (2) Incisor

(3) Molar (4) Premolar

8. Pulp cavity of teeth is lined by :

(1) Odontoblast (2) Chondroblast

(3) Osteoblast (4) Amyloblast

DIGESTIVE GLANDS

9. In human being sphincter of Oddi is situated in :-

(1) Common bile duct

(2) Ampulla of vater

(3) Main pancreatic duct

(4) Common hepatic duct

10. Ptyalin is secreted by-

(1) Stomach (2) Salivary gland

(3) Pancreas (4) Bile

11. Ptyalin, an enzyme work in saliva in –

(1) Alkaline medium

(2) almost neutral medium

(3) Acidic medium

(4) all media

12. In pancrease, pancreatic juice and hormone are secreted by-

(1) Same cells

(2) Different Cells

(3) Same cells at different times

(4) None of these.

13. C-shaped widest part of intestine

(1) Pancreas (2) Liver

(3) Duodenum (4) Thyroid

14. Which substance of saliva destroy the harmful bacteria-

(1) Cerumin (2) Chyme

(3) Lysozyme (4) Secretin

15. One of the following is not a constituent of saliva :-

(1) Bicorbonate (2) Lysozyme

(3) Glucose (4) Immunoglobulin

16. What statement is wrong about bile :-
(1) Is necessary for fat digestion
(2) Is stored in the gall bladder
(3) Is important only for normal digestion of sugar
(4) None of above

17. 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

18. Crypts of Leiberkuhn are found in between the villi. They secrete :
(1) Glucagon
(2) Succus entericus
(3) Insulin
(4) None

19. Parotid salivary gland are present :
(1) Below the tongue
(2) Below the ear
(3) Below the eye orbit
(4) In the angle between two jaws

20. Sinusoids are found in :
(1) Liver (2) Kidney
(3) Heart (4) Blood

21. Specific cells found in liver are :
(1) Enterocyte cells
(2) Beta cells
(3) Hepatic cells
(4) Islets of Langerhans

22. Cells of liver which act as phagocytes are :
(1) Dieter's cells (2) Kupffer's cells
(3) Hensen cells (4) Aciner cells

PHYSIOLOGY OF DIGESTION AND OTHERS

23. Casien present in milk,which is –
(1) bacterium (2) sugar
(3) protein (4) fat

24. Amylase enzyme acts on the -
(1) Starch (2) Protein
(3) Fat (4) Cane sugar

25. Liver cells secrete-
(1) amylopsin (2) trypsin
(3) lipase
(4) bile and no enzyme

26. Peristaltic movements found in different parts of alimentary canal in which one of these there is least peristalsis-
(1) Stomach (2) duodenum
(3) rectum (4) Oesophagus

27. Milk protein is curdled into calcium paracacinate by-
(1) Maltose (2) Rennin
(3) Trypsin (4) lactose

28. The enzyme invertase hydrolyse-
(1) Glucose into sucrose
(2) Sucrose into glucose and fructose
(3) Starch into maltose
(4) Starch into sucrose

29. Amino acids are absorbed in-
(1) Blood cappillaries of villi
(2) Wall of rectum
(3) lacteals and blood capillaries of villi
(4) lacteals of villi

30. Digestion of carbohydrate is affected by-
(1) Amylopsin (2) Lipase
(3) Erepsin (4) Pepsin

31. Trypsin is secreted by-
(1) Pancreas (2) Stomach
(3) Liver (4) Ileum

32. Proteins are broken down into amino acids in-
(1) Buccal cavity (2) Stomach
(3) Intestine (4) Rectum

33. Which reserve food is consumed by man during starvation :-
(1) Fat (2) Protein
(3) Glycogen (4) Vitamin

34. Ptyalin cannot work in stomach, because it becomes-
(1) Inactive due to HCl
(2) Inactive due to Rennin
(3) Inactive due to Pepsin
(4) None of these

35. What is the important function of bile-
(1) For digestion by emulsification of fats
(2) Elimination of excretory products
(3) For digestion by enzymes
(4) Coordination of digestive activities

36. Some proteolytic enzymes are-
(1) Trypsin, Erepsin, Pepsin
(2) Amylase, Lipase, Zymase
(3) Ampylopsin, Steapsin, Ptyalin
(4) Urease, Dehydrogenase, Zymase

37. Succus entericus is secreted by-
(1) Gastric glands
(2) Islets of langerhans
(3) Crypts of lieberkuhn & Brunner's gland
(4) Goblet cells

38. Glycogen is stored in-
(1) Blood (2) Liver
(3) Lungs (4) Kidney

39. Chymotrypsin is-
(1) Proteolytic enzyme
(2) Fat digestive enzyme
(3) Vitamin
(4) Hormone

40. Emulsification of fats by bile takes place in-
(1) Duodenum (2) Liver
(3) Stomach (4) Intestine

41. Absorption of digested food chiefly occurs in-
(1) Stomach (2) Colon
(3) Small Intestine (4) Large Intestine

42. The enzyme trypsinogen is secreted from-
(1) Duodenum (2) Pancreas
(3) Liver (4) Stomach

43. Enzyme pepsin acts upon food at a pH of about-
(1) 3 to split proteins
(2) 2 to split carbohydrate
(3) 7 to change protein into peptones
(4) 2 to change protein in amino acids

44. Our food mainly contains-
(1) Carbohydrates (2) Cellulose
(3) Sucrose (4) Glucose

45. Which one is differ from the category of other three-
(1) Gastrin (2) Glucagon
(3) Secretin (4) Ptyalin

46. A carbohydrate splitting enzyme is secreted by -
(1) Liver
(2) Zymogen cells of gastic glands
(3) Spleen
(4) Crypts of Lieberkuhn

47. Stomach is the main site for the digestion of -
(1) Fats (2) Carbohydrate
(3) Protein (4) All of these

48. The hormone involved in the discharge of pancreatic juice in mammal is called-
(1) Gastrin (2) Secretin
(3) Secretin & CCK (4) Enterogasterone

49. Function of HCl in stomach is to-
(1) Kill micro-organism of food
(2) Facilitate absorption of food
(3) Dissolve enzymes secreted by gastric glands
(4) Active trypsinogen to trypsin

50. Enzyme maltase in human gut acts on food at a pH of –
(1) More than seven to change starch into maltose.
(2) Less than 7 to change starch into maltose.
(3) More than 7 to change maltose into glucose.
(4) Less than 7 to change maltose into glucose.

51. Simple sugar of blood is-
(1) Galactose (2) Lactose
(3) Sucrose (4) Glucose

52. During prolonged starvation, body derives nutrition from storage of -
(1) Liver and adipose tissue
(2) Spleen
(3) Liver and lungs
(4) Subcutaneous fat and Pancreas

53. Enterokinase stimulates which of the following-
(1) Pepsinogen (2) Trypsin
(3) Pepsin (4) Trypsinogen

54. Maximum digestion of food take place in-
(1) Stomach (2) Jejunum
(3) Colon (4) Duodenum

55. Absence of which of these in bile will make fat digestion difficult-
(1) Cholesterol (2) Bile salts
(3) Pigment (4) Acids

56. Pancreatic juice is released into-
(1) Duodenum (2) Ileum
(3) Stomach (4) Jejunum.

57. The enzyme that catalyse the changing of emulsified oils to fatty acids and glycerol is-
(1) Pepsin (2) Lipase
(3) Amylase (4) Sucrose

58. Point out the odd one-
(1) Rennin (2) Secretin
(3) Calcitonin (4) Oxytocin

59. Pancreatic lipase acts upon-
(1) Glycogen (2) Triglycerides
(3) Dissacharides (4) Polypeptides

60. Bile is formed in-
(1) Gall bladder (2) Liver
(3) Spleen (4) Blood

61. Cholecystokinin is secretion of
(1) Duodenum that causes contraction of gall bladder
(2) Goblet cells of ileum stimulates secretion of succus entricus
(3) Liver and controls secondary sex characters
(4) Stomach that stimulates pancreas to release juice

62. Enzyme trypsinogen is changed to trypsin by
(1) Gastrin (2) Enterogastrone
(3) Enterokinase (4) Secretin

63. Castle's intrinsic factor is connected with internal absorption of-
(1) Pyridoxine (2) Riboflavin
(3) Thiamine (4) Cobalamine

64. Maximum number of enzymes occur in-
(1) Omnivorous
(2) Herbivores
(3) Carnivores
(4) None of the above

65. Cholesterol is synthesized in-
(1) Brunner's gland (2) Liver
(3) Spleen (4) Pancreas

66. Rennin acts on-
(1) Milk changing casein into calcium paracaseinate at 7.2 - 8.2 PH
(2) Proteins in stomach
(3) Fat in intestine
(4) Milk changing casein into calcium paracascinate at 1-3 pH

67. Lacteals take part-
(1) Digestion of milk
(2) Absorption of fat
(3) Digestion of lactic acid
(4) None of the above

68. Muscular contraction of alimentary canal are-
(1) Circulation (2) Deglutition
(3) Churning (4) Peristalsis

69. Fatty acids and glycerol are first absorbed by-
(1) Lymph vessels
(2) Blood
(3) Blood capillaries
(4) Hepatic portal Vein

70. During prolonged fasting-
(1) First fats are used up, followed by carbohydrate from liver and muscles, and protein in the end
(2) First carbohydrate are used up, followed by fat and proteins towards end
(3) First lipids, followed by proteins and carbohydrates towards end.
(4) None of the above

71. Which of the following is absorbed in ileum-
(1) Fat (2) Bile salts
(3) Vit-K (4) Glucose

72. Which food substance is absorbed, without digestion-
(1) Carbohydrates (2) Proteins
(3) Vitamins (4) Fats

73. Mucus is secreted by the :-
(1) Stomach (2) Duodenum
(3) Large intestine (4) All of the above

74. Water absorption is mainly occur in :-
(1) Colon (2) Intestine
(3) Gastrium (4) Appendix

75. Which of the following is absorbed in proximal intestine :-
(1) Iron (2) sodium
(3) Bile salts (4) Vitamin B_{12}

76. Substances which are not related with hepaticportal circulation :-
(1) Amino acid (2) Fatty acid
(3) Glucose (4) Fructose

77. Jaundice is a disorder of :
(1) Skin and eyes (2) Digestive system
(3) Circulatory system
(4) Excretory system

78. Lactose composed of :-
(1) Glucose + galactose
(2) Glucose + fructose
(3) Glucose + glucose
(4) Glucose + mannose

79. If for some reason the parietal cells of the gut epithelium become partially non-functional, what is likely to happen ?
(1) The pH of stomach will fall abruptly
(2) Steapsin will be more effective
(3) Proteins will not be adequately hydrolysed by pepsin into proteoses and peptones
(4) The pancreatic enzymes and specially the trypsin and lipase will not work efficiently

80. In stomach after physical and chemical digestion food is called:-
(1) Chyme (2) Chyle
(3) Amino acid (4) Bolus

81. Fully digested food reaches to liver by
(1) Hepatic portal vein
(2) Hepatic artery
(3) Hepatic vein
(4) All the above

82. A person who is eating rice. His food contains
(1) Cellulose (2) Starch
(3) Lactose (4) Protein

83. In mammals milk is digested by action of-
(1) Rennin (2) Amylase
(3) Intestinal bacteria (4) Invertase

84. Stool of a person contain whitish grey colour due to malfunction of which type of organ:
(1) Pancreas (2) Spleen
(3) Kidney (4) Liver

85. Which of the following is a dissacharide :
(1) Glucose (2) Fructose
(3) Sucrose (4) Galactose

86. If all the peptide bonds of protein are broken, then the remaining part is :-
(1) Amide
(2) Oligosaccharide
(3) Polypeptide
(4) Amino acid

87. Hydrolysis of lipid yields :-
(1) Fats
(2) Fatty acids and glycerol
(3) Mannose and glycerol
(4) Maltose and fatty acid

88. Glucose and galactose unite to form
(1) Maltose (2) Sucrose
(3) Isomaltose (4) Lactose

89. Gastric enzyme pepsin acts only in acidic medium with in a limited pH concentration. It varies:
(1) 1.20 to 1.80 (2) 1.00 to 1.50
(3) 2.00 to 2.50 (4) 1.50 to 2.60

90. Stomach in vertebrates is the main site for digestion of :
(1) Proteins (2) Carbohydrates
(3) Fats (4) Nucleic acids

91. The chief function of bile is to :
(1) Digest fat by enzymatic action
(2) Emulsify fats for digestion
(3) Eliminate waste products
(4) Regulate digestion of proteins

92. The toxic substance are detoxicated in the human body by :
(1) Lungs (2) Kidneys
(3) Liver (4) Stomach

93. The end product of carbohydrate metabolism is :
(1) CO_2 and H_2O (2) NH_3 and CO_2
(3) NH_3 and H_2O (4) CO_2

94. The muscular contraction in the alimentary canal is known as :
(1) Systole (2) Diastole
(3) Peristalsis (4) Metachronal

95. End products of protein hydrolysis are :
(1) Mixture of amino acids
(2) Sugars
(3) Peptides (4) 25 amino acids

96. Ptyalin is an enzyme of
(1) Salivary juice (2) Pancreatic juice
(3) Instestinal juice (4) None of these

97. The hormone 'secretin' stimulates secretion of
(1) Pancreatic juice (2) Bile juice
(3) Salivary juice (4) Gastric juice

98. Which one of the following amino acids is not found in proteins ?
(1) Arginine (2) Ornithine
(3) Aspartic acid (4) Tyrosine

99. Succus entericus is also called are:
(1) Gastric juice (2) Intestinal juice
(3) bile juice (4) Saliva

100. Just as hydrochloric acid is for pepsinogen, so is the :
(1) haemoglobin to oxygen
(2) enterokinase to typsinogen
(3) bile juice to fat
(4) glucagon to glycogen

101. Where the lysozymes are found :
(1) In saliva and tears both
(2) In tears
(3) In saliva
(4) In mitochondria

102. The hormone which lowers the secretion of hydro chloric acid and gastric juice is :
(1) Secretin (2) Enterogastrone
(3) Enterokinin (4) Gastrin

103. Trypsin differs from pepsin because it digests :
(1) Carbohydrate in alkaline medium in stomach
(2) Protein, in alkaline medium in stomach
(3) Protein, in acidic medium of stomach
(4) Protien, in alkaline medium in duodenum

104. Pancreatic juice is :
(1) alkaline in nature
(2) Acidic in nature
(3) enzymatic in nature
(4) Both acidic and alkaline in nature

105. Bilirubin and Biliverdin are present in :
(1) Pancreatic Juice (2) Saliva
(3) Bile juice (4) Intestinal juice

106. The amount of gastric juice secreted per day from man's stomach is about :
(1) 500 ml. to 1000 ml
(2) 2000 ml to 3000 ml
(3) 100 ml to 500 ml
(4) 10 ml to 15 ml

107. The function of enterogasterone hormone is :
(1) to control excretion
(2) to inhibit gastric juice secretion
(3) regulate the absorption of food
(4) to stimulate gastric glands to release gastric juice

108. What is the common passage for bile and pancreatic juices
(1) Ampulla of Vater
(2) Ductus Choledochus
(3) Duct of Wirsung
(4) Duct of Santorini

109. Pepsinogen is secreted from :
(1) argentaffin cells (2) goblet cells
(3) chief cells (4) parietal cells

110. Cells of the pancreas is not digested by their own enzymes because :
(1) enzymes are secreted in inactive form
(2) cells are lined by mucous membrane
(3) enzymes are released only when needed
(4) none of the above

111. Secretin :
(1) Stimulates enzymes secretion by pancreas, inhibits acid secretion in stomach, stimulates gall bladder
(2) Stimulates bicarbonate secretion by pancreas, inhibits acid secretion in stomach, stimulates bicarbonate secretion by liver
(3) Stimulates acid secretion in stomach, potentiates action of CCK, inhibits intestinal movement
(4) Stimulates gall bladder, inhibits acid secretion in stomach, stimulates bicarbonate secretion by pancreas

112. Vitamins are –
(1) Inorganic substances and can't be synthesized by animals.
(2) Inorganic substances and can be synthesized by animals.
(3) Organic substances which cannot mostly be synthesized by animals.
(4) Organic substances which can mostly be synthesized by animals.

113. Which should not be eaten too much during hot months-
(1) Vitamins (2) Fats
(3) Mineral salts (4) Proteins

114. To get ample supply of carbohydrates, one should eat –
(1) Meat (2) gram
(3) Carrots (4) Rice

115. Protein are mainly required in the body for-
(1) Growth (2) Repair
(3) Both of these (4) None of these

116. A person deficient in Rhodopsin (visual pigment) should take-
(1) Tomatoes (2) Radish
(3) Carrot (4) Guavas

117. Rickets is caused by the deficiency of-
(1) Vit A (2) Vit C
(3) Vit D (4) Vit B

118. Pernicious anaemia is caused by deficiency of vitamin-
(1) C (2) B_1 (3) B_{12} (4) B_6

119. Another substance of the category of glucose, sucrose and maltose is-
(1) Myoglobin (2) Starch
(3) Amino acids (4) Haemoglobin

120. A person with bleeding gums should daily take-
(1) Milk (2) Carrots
(3) Lemons (4) Butter

121. Rickets is disease of which category-
(1) Infective disease
(2) Deficiency disease
(3) Communicable disease
(4) Inheritable disease

122. Thiamine is another name for-
(1) Vit B_2 (2) Vit A
(3) Vit B_1 (4) Vit B Complex

123. Vit D is also called-
(1) Calciferol (2) Ascorbic acid
(3) Retinol (4) Folic Acid

124. In mammals carbohydrate are stored in the form of-
(1) Lactic acid in muscles
(2) Glycogen in liver and muscles
(3) Glucose in liver and muscles
(4) Glycogen in liver and spleen

125. Which pairing is not correct-
(1) Vit D-Rickets
(2) Vit K-Sterlity
(3) Thiamine-Beri-Beri
(4) Niacin-Pellagra

126. Bow - shaped legs in children are due to deficiency of Vitamin-
(1) D (2) A (3) B (4) C

127. Beri-Beri, Scurvy and Rickets are respectively caused by deficiency of -
(1) B, D & C (2) B, C & D
(3) D, B & A (4) A, D & C

128. Vit K is a required for-
(1) Change of Prothrombin to thrombin
(2) Synthesis of Prothrombin
(3) Change of Fibrinogen to Fibrin
(4) Formation of thromboplastin

129. Dermatitis, diarrhoea and dementia are seen in deficiency of :-
(1) Thiamine (2) Riboflavin
(3) Niacin (4) Foliate

130. The vitamin that is useful in cancer is vitamin :-
(1) A (2) B_{17}
(3) C (4) All of these

131. Vitamin which induces maturation of R.B.C.:-
(1) B_1 (2) A (3) B_{12} (4) D

132. Which one is wrong pair :-
(1) Scurvy – Vitamin C
(2) Rickets – Vitamin D
(3) Night blindness (Xerophthalmia) – Vitamin A
(4) Beriberi – Vitamin K

133. Which one correctly matched :-
(1) Vit. E – Tocoferol
(2) Vit. D – Riboflavin
(3) Vit. B – Calciferol
(4) Vit. A – Thiamine

134. Vitamin–C is :–

(1) Ascorbic acid (2) Citric acid

(3) Phosphoric acid (4) Glutamic acid

135. Which one of the following is the correct matching of a vitamin, its nature and its deficiency disease :

(1) Vitamin K–Fat soluble–Beri–Beri

(2) Vitamin A–Fat soluble–Beri–Beri

(3) Vitamin K– Water soluble–Pellagra

(4) Vitamin A – Fat soluble–Night blindness

136. Scurvy disease is due to the :

(1) Presence of h-factor in blood

(2) Deficiency of vitamin E

(3) Virus

(4) Deficiency of vitamin C

137. In adults the deficiency of vitamin D causes :

(1) Rickets (2) Beri-beri

(3) Scurvy (4) Osteomalacia

138. Which of the following vitamin synthesise in animal body by bacteria :

(1) C (2) A (3) E (4) B_{12}

139. Marasmus disease is caused due to :

(1) Protein deficiency

(2) Obesity

(3) Dwarfism

(4) Deficiency of vitamins

140. Which of the following does not belong to vitamin B group :

(1) Riboflavin

(2) Nicotin

(3) Cyanocobalamine

(4) Tocopherol

141. Certain B vitamins are:

(1) Enzymes

(2) Co-enzymes

(3) Hormone

(4) Digestive substance

142. Deficiency of thiamine causes :

(1) Beri-beri (2) Rickets

(3) Caries (4) Pellagera

143. Vitamin C is helpful in the :

(1) Formation of visual pigment

(2) Growth of bones

(3) Treatment of pernicious anaemia

(4) Wound healing

EXERCISE-II

1. Which one of the following pairs of the type of cells and their secretion is correctly matched :– **[AIIMS 2006]**
(1) Oxyntic cells – a secretion with pH between 1.2 and 3.0
(2) Alpha cells of Islets of Langerhans – secretion that decreases blood sugar level
(3) Kupffer cells – a digestive enzyme that hydrolyses nucleic acid
(4) Sabaceous glands – a secretion that evaporates for cooling

2. Which one of the following is a fat–soluble vitamin and its relate deficiency disease ? **[AIPMT 2007]**
(1) Calciferol – Pellagra
(2) Ascorbic acid – Scurvy
(3) Retinol – Xerphthalmia
(4) Cobalamine – Beri–Beri

3. Which one of the following is the correct matching of the site of action on the given substrate, the enzyme acting upon it and the end product : **[AIPMT 2008]**
(1) Small intestine : proteins $\xrightarrow{\text{pepsin}}$ amino acids
(2) Stomach : fats $\xrightarrow{\text{lipase}}$ micelles
(3) Duodenum : tryglycerides $\xrightarrow{\text{trypsin}}$ monoglycerides
(4) Small intestine : starch $\xrightarrow{\alpha-\text{amylase}}$ disaccharide (maltose)

4. What will happen if the secretion of parietal cells of gastric glands is blocked with an inhibitor : **[AIPMT 2008]**
(1) In the absence of HCl secretion in active pepsiogen is not converted into the active enzyme pepsin
(2) enterokinase will not be released from the duodenal mucosa and so trypsinogen is not converted to trypsin
(3) Gastric juice will be deficient in chymosin
(4) Gastric juice will be deficient in pepsinogen

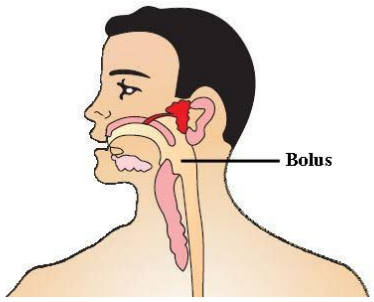
5. Which one of the following pairs of food components in humans reaches the stomach totally undigested **[AIPMT 2009]**
(1) Starch and cellulose
(2) Protein and starch
(3) Starch and fat
(4) Fat and cellulose

6. A young infant that feed entirely on mother's milk which is colour but the stools which the infant passes out is quite yellowish. This yellow colour due to ? **[AIPMT 2009]**
(1) Pancreatic juice poured into duodenum
(2) Intestinal juice
(3) Bile pigments passed through bile juice
(4) Undigested milk protein casein

7. Which is true about gastric glands ? **[AIPMT 2009]**
(1) Peptic cells secrete pepsin
(2) Oxyntic cells secrete HCl and castle's intrinsic factor, those are responsible for vit B_{12} absorption.
(3) Mucosa cells secrete mucous and intrinsic factor responsible for vit B_{12} absorption.
(4) Pepsinogen digests protein into peptons and proteoases.

8. A young person is suffering from cancer in tongue. His tongue is completely removed, then which of the following situation will describe the person that he will be able to – **[AIIMS 2011]**
(1) Taste sweet & salty.
(2) Not able to taste sweet, but able to taste salty.
(3) Perceive the odour of rose but not able to taste sweet and salt.
(4) Taste sweet and salty, but not perceive to the odour of rose.

9. What is the real sense inflected in the given diagram ? **[AIIMS 2011]**



(1) Closure of oesphagus for the entry of food in stomach
(2) Closure of trachea by epiglottis for preventing food to enter in it
(3) Movement of bolus in trachea
(4) Movement shown is a reflex action

10. The initial step in the digestion of milk in humans is carried out by? **[AIPMT 2014]**
(1) Lipase (2) Trypsin
(3) Rennin (4) Pepsin

11. Gastric juice of infants contains :– **[AIPMT 2015]**
(1) Nuclease, pepsinogen, lipase
(2) pepsinogen, lipase, rennin
(3) amylase, rennin, pepsinogen
(4) maltase, pepsinogen, rennin

12. In the stomach, gastric acid is secreted by the :– **[NEET-I 2016]**
(1) gastrin secreting cells
(2) parietal cells
(3) peptic cells (4) acidic cells

13. Which of the following guards the opening of hepatopancreatic duct into the duodenum? **[NEET-I 2016]**
(1) Semilunar valve (2) Ileocaecal valve
(3) Pyloric sphincter (4) Sphincter of Oddi

14. Which hormones do stimulate the production of pancreatic juice and bicarbonate? **[NEET-II 2016]**
(1) Cholecystokinin and secretin
(2) Insulin and glucogen
(3) Angiotenin and epinephrine
(4) Gastrin and insulin

15. Pancrease secretes :– **[AIIMS 2016]**
(1) Steroid hormones only
(2) Protenacious hormones only
(3) Both steroids and peptide hormones
(4) None of these

16. Cholecystokinin (CCK) helps in secretion of :– **[AIIMS 2016]**
(1) Alkaline buffer
(2) Pancreatic enzymes
(3) Gastric secretion
(4) Water ad bicarbonate ions

17. Which cells of "Crypts of Lieberkuhn" secrete antibacterial lysozyme ? **[NEET (UG) 2017]**
(1) Paneth cells (2) Zymogen cells
(3) Kupffer cells (4) Argentaffin cells

18. Which of the following options best represents the enzyme composition of pancreatic juice ? **[NEET (UG) 2017]**
(1) amylase, pepsin trypsinogen, maltase
(2) peptidase, amylase, pepsin, rennin
(3) lipase, amylase, pepsin, rennin
(4) amylase peptidase, trypsinogen, rennin

19. A body boy aged two years in admitted to play school and passes through a dental check–up. Thhe dentist observed that the boy had twenty teeth. Which were absent ? **[NEET (UG) 2017]**
(1) Canines (2) Pre-molars
(3) Molars (4) Incisors

20. Bile juice is secreted by stimulation of :– **[AIIMS 2017]**
(1) Gastrin (2) Secretin
(3) Estrerokinase (4) CCK

21. If the pH of duodenum decreases below 5, than secretion of _____ stop. **[AIIMS 2017]**
(1) Secretin (2) Enterokinase
(3) CCK (4) Gastrin

EXERCISE-III

1. Select the incorrect statements :-
(a) alimentary canal begins with an anterior cavity called buccal cavity.
(b) tooth is embedded in a socket of mandible bone only.
(c) human shows strict diphyodont type of dentition.
(d) oesophagus and the trachea open into the pharynx.
(1) a, b, c & d (2) a, b & c
(3) a, c & d (4) a, b & d

2. The oesophagus is a thin, long tube which extends _____ passing through the neck.
(1) anteriorly (2) posteriorly
(3) horizontaly (4) obliquely

3. In human _____ is a small blind sac which hosts some symbiotic micro-organism.
(1) Caecum (2) Colon
(3) Rumen (4) All of these

4. Select the correct structural sequence of alimentary canal facing from inside to outside.
(1) Serosa → Muscularis → Submucosa → Mucosa
(2) Muscularis→ Serosa → Mucosa → Submucosa
(3) Mucosa→ Submucosa → Muscularis → Serosa
(4) Submucosa → Mucosa → Muscularis → Serosa

5. All of the following are correct with respect to intestine of human except.
(1) Colon having ascending, descending and transeverse part.
(2) Duodenum is U-shaped structure
(3) Taenae & haustra is present all along the length of intestine.
(4) Highly developed villi is restricted to small intestine.

6. Select the correct statements.
(a) Salivary glands situated just outside the buccal cavity.
(b) Liver is the largest digestive gland.
(c) Hepatic duct not arises from gall bladder.
(d) Sphincter of oddi can regulate the released of pancreatic and bile duct in duodenum.
(1) a, b, c & d (2) a, b & d
(3) b, c & d (4) a, b & c

7. The process of digestion is acomplished by :-
(1) Mechanical process
(2) Chemical process
(3) Electrical process
(4) Both 1 & 2

8. Which of the following helps in lubricating and adhering the masticated food particles into a bolus.
(1) Salivary amylase
(2) Mucous
(3) Secretion of lacrymal gland
(4) Gastric juice

9. Which of the following electrolytes present in saliva of human?
(1) Na^+ (2) K^+
(3) Cl^- (4) above all

10. Select the correct statements.
(1) Trypsinogen $\xrightarrow{\text{Chymotrypsin}}$ Trypsin
(2) Procarboxy peptidase $\xrightarrow{\text{Pepsin}}$ carboxypeptidase
(3) Proamylase $\xrightarrow{\text{Ptylin}}$ Amylase
(4) Pepsinogen $\xrightarrow{\text{HCl}}$ Pepsin

11. Select the odd with respect to enzymes present in adult human.

(1) Rennin (2) Renin

(3) Trypsin (4) Pepsin

12. Which of the following is not produced by the brush border cells of the intestinal mucosa.

(1) dipeptidases
(2) nucleosidases
(2) lipases
(4) steapsin

13. All of the following is correct w.r.t. large intestine except.

(1) No significant digestive activity.

(2) Absorption of some water

(3) Absorption of certain minerals.

(4) Absorption of remaining glucose and amino acid.

14. In which of the following disease liver is affected, skin and eyes turn yellow due to the deposit of bile pigments.

(1) Vomiting (2) Jaundice

(3) Diarrhoea (4) Dyssentry

15. Match the following :–

	Column I		Column II
(A)	Salivary gland	(i)	Trypsinogen
(B)	Stomach	(ii)	Bile pigments
(C)	Pancreas	(iii)	Saliva
(D)	Intestine	(iv)	Erepsin
(E)	Gall bladder	(v)	Gastric juice

(1) A-v, B-iii, C-i, D-ii, E-iv

(2) A-iii, B-v, C-iv, D-iv, E-ii

(3) A-iv, B-iii, C-ii, D-i, E-v

(4) A-ii, B-v, C-i, D-ii, E-iv

16. Find out the correct match from the following table :–

	Column-I	Column-II	Column-III
A	Goblet Cells	Mucus	Prevent mucosa layer from damage of HCl
B	Lysozyme	Saliva	Antibacterial agent
C	Saliva	Subparotid gland	Secrete salivary amylase
D	Oxyntic cells	HCl	Stimulate gastric lipase

(1) Only 'A' (2) A and B

(3) Only C (4) C and D

17. Which of the following statements is/are incorrect regarding digestion and absorption of food in human beings :-

(a) About 90% starch is hydrolysed by salivary amylase in our oral cavity

(b) Entero-endocrine cells in our stomach secrete the proenzyme trypsinogen

(c) Vitamin-D is produced in human body in skin

(d) Bile salts act as activator of pancreatic lipase

(1) Two, a and b (2) Two, a and c

(3) Two, a and d (4) Three, a, b and d

18. Largest internal organ of the body is :–

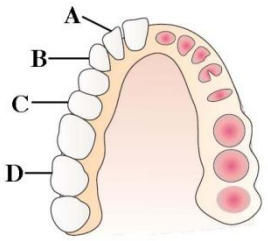
(1) Skin

(2) Liver

(3) Pancreas

(4) Small intestine

19. Identify A, B, C and D and choose correct option regarding their number in upper jaw :–



	A	B	C	D
(1)	Incisor-2	Canine-2	Premolar-2	Molar-3
(2)	Incisor-4	Canine-4	Premolar-8	Molar-12
(3)	Incisor-4	Canine-2	Premolar-4	Molar-6
(4)	Incisor-2	Canine-1	Premolar-2	Molar-3

20. Identify the correct match from the column I, II and III.

	Column-I		Column-II		Column-III
A	Salivary gland	a	Lacteal	i	Emulsification
B	Villi	b	Goblet cells	ii	Wharton's duct
C	Intestinal epithelium	c	Bile juice	iii	Absorption of fat
D	Liver	d	Sub maxillary gland	iv	Mucous

21. Read the following statement (A-D)

(A) The stomach stores the food for 4-5 hours

(B) The food mixes thoroughly with the acidic intestinal juice

(C) Trypsinogen is activated by an enzyme-enterogastrone, secreted by the intestine mucosa

(D) Rennin is enzyme found in gastric juice of infants which help in digestion of milk protein

How many of th above statements are wrong ?

(1) Four (2) One (3) Two (4) Three

22. Conversion of large fat globules into smaller globule is :–

(1) Emulsification (2) Digestion

(3) Assimilation (4) Specification

23. Micelle formation occurs in :–

(1) Enterocyte (2) Duodenum

(3) Lacteals (4) Pancreas

24. Chymotrypsinogen is produced by

(1) Liver (2) Pancreas

(3) Stomach (4) Duodenum

25. Contraction of gall bladder is carried by :

(1) citric acid + acetyl Co-A

(2) gastrin

(3) cholecystokinin

(4) none of these

26. A person addict for alcohol gets his liver destroyed because :

(1) Liver stores excess of protein

(2) Liver stores excess of fat

(3) Liver stores excess of starch

(4) Liver stores excess of glycogen

27. Anti-sterility vitamin is :

(1) Vitamin B_{12} (2) Vitamin D

(3) Vitamin E (4) Vitamin A

28. The longitudinal muscular folds of inner wall of stomach are called :

(1) Papilla of vater (2) Rugae

(3) Villi (4) Fissure

29. Deamination occurs in :

(1) Kidney (2) Liver

(3) Nephron (4) Both '1' and '2'

30. Enterogastrone is :

(1) Hormone secreted by mucosa

(2) Enzyme secreted by mucosa

(3) Hormone secreted by duodenal mucosa

(4) Secreted by endocrine gland related to digestion

31. Part of bile juice useful in digestion is :
(1) Bile salt (2) Bile pigment
(3) Bile matrix (4) All of them

32. From which of the following pepsin is secreted :
(1) Lungs (2) Stomach
(3) Salivary gland (4) Sebaceous gland

33. Secretin hormone stimulates :
(1) Gastric glands (2) Pancreas
(3) Gall bladder
(4) Crypts of Lieberkuhn

34. Prorennin is secreted by :
(1) zymogen cells (2) sertoli cells
(3) islets of langerhans
(4) hepatacytes

35. Fint out the correctly matched pair :
(1) Pepsinogen → Zymogenic cells
(2) HCl → Goblet cells
(3) Mucous → Oxyntic cells
(4) Pancreatic → Salivary glands
(5) Ptyalin → Acinar cells

36. Among mammals, a significant role in the digestion of milk is played by :
(1) Rennin (2) Invertase
(3) Amylase (4) Intestinal bacteria

37. pH of gastric juice is :
(1) 2 (2) 4 (3) 6 (4) 8

38. Which of the following hormone helps in secretion of HCl from stomach ?
(1) renin (2) gastrin
(3) secretin (4) somatomedin

39. Which of the following vitamins are fat soluble?
(1) A, B, C, K (2) A, B, D, E
(3) A, D, E, K (4) A, D, C, K

40. The organ in human body where glycogenolysis takes place?
(1) muscles (2) liver
(3) small intestine (4) kidney

41. 'Crypts of Lieber kuhn' are found in :
(1) gall bladder (2) liver
(3) pancreas (4) intestinal glands

42. Glisson's capsule is asociated with :
(1) liver (2) pancreas
(3) lungs (4) kidney

43. The main digestive function of enterokinase is :
(1) conversion of pepsinogen into pepsin
(2) conversion of trypsinogen into trypsin
(3) conversion of trypsin into trypsinogen
(4) stimulation of the gastric glands to secrete gastric juice

44. Osteomalacia occurs due to the deficiency of :
(1) Vitamin A (2) Vitamin B
(3) Vitamin C (4) Vitmina D

45. Vitamin B_{12} consists of which type of mineral ?
(1) Co (2) Ni
(3) Fe (4) None of these

46. Pancreatic juice contain bicarbonate which is secreted by :
(1) paneth cells (2) goblet cell
(3) kupffer's cell (4) aciner cell

47. Identify the false statement :
(1) oesophagus does not secrete any enzyme
(2) gall bladder is absent in horse
(3) human teeth are thecodont
(4) there are two pairs of salivary glands in humans

48. Which of the following is a water suluble vitamin?
(1) Vitamin A (2) Vitamin B
(3) Vitamin D (4) Vitamin E

49. Find out the correct match :

Column I	Column II
A. Hepatic lobule	i. Sub mucosal glands
B. Brunner's glands	ii. Base of villi
C. Crypts of lieberkuhn	iii. Glisson's capsule
D. Sphincter of Oddi	iv. Gall bladder
E. Cystic duct	v.Hepatopancreatic duct
	vi. Serous glands

	A	B	C	D	E
(1)	iii	vi	ii	v	iv
(2)	v	ii	iii	vi	i
(3)	iii	i	ii	v	iv
(4)	iv	vi	v	ii	i
(5)	iv	ii	vi	v	iii

50. It s present in rod cells and useful in night vision :
(1) vitamin K (2) melanin
(3) rhodopsin (4) vitamin C

51. Secretin and cholecystokinin are digestive hormones. They are secreted in:
(1) Oesophagus (2) Ileum
(3) Duodenum (4) Pyloric stomach

52. Identify the false statement ?
(1) bile is secreted by gall bladder
(2) fundic stomach is the site of digestion
(3) parietal cell lie in wall of stomach
(4) bile is secreted by liver

53. Which part of body secretes the hormone secretin?
(1) stomach (2) oesophagus
(3) illeum (4) duodenum

54. Gluconeogenesis is :
(1) formation of ammonia from glucose
(2) breakdown of glucose
(3) formation of glycogen
(4) formation of glucose from sources other than carbohydrate

55. Kwashiorkar disease is due to deficiency of :
(1) protein (2) fat
(3) sugar (4) hormone

56. Carbohydrate digestion occurs first in which structure?
(1) mouth (2) intestine
(3) stomach (4) none of these

57. Enzyme pepsin acts in :
(1) acidic medium in the pancreas
(2) acidic medium in the stomach
(3) intestine
(4) mouth

58. Bile secretion is propotional to the concentration of :
(1) protein (2) fat
(3) carbohydrate (4) none of these

59. Digestive enzymes are :
(1) hydrolase (2) oxido-reductase
(3) transferase (4) none of these

60. Protein deficiency leads to :
(1) Kwashiorkar (2) Marasmus
(3) Cretinism (4) both (1) and (2)

61. Pepsinogen is secreted by :
(1) chief-cells (2) oxyntic cells
(3) mast cells (4) parietal cells

62. In mammals the teeth are
(a) of different types
(b) embedded in the cuplike socket in the jaw bones
(c) only two sets, present throughout life
The condition are referred as :
(1) heterodont, thecodont, diphyodont
(2) thecodont, heterodont, diphyodont
(3) diphyodont, thecodont, heterodont
(4) heterodont, diphyodont, thecodont

63. Which of the following process will be affected by the absence of enterokinase?
(1) Lipid $\rightarrow$ Fatty acid + glycerol
(2) Dipeptides $\rightarrow$ Amino acid
(3) Proteoses $\rightarrow$ Dipeptide
(4) Amylose $\rightarrow$ Maltose

ANSWER KEY

EXERCISE–I

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	**3**	**1**	**1**	**1**	**1**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	**3**	**2**	**3**	**1**	**4**	**3**	**2**	**2**	**1**	**1**	**1**	**3**	**1**	**1**	**1**	**1**	**3**	**2**	**1**	**1**
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	**3**	**2**	**1**	**1**	**4**	**4**	**3**	**3**	**1**	**3**	**4**	**1**	**4**	**4**	**2**	**1**	**2**	**1**	**2**	**2**
Que.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	**1**	**3**	**4**	**1**	**2**	**4**	**2**	**4**	**1**	**2**	**2**	**3**	**4**	**2**	**1**	**2**	**2**	**1**	**3**	**1**
Que.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	**1**	**2**	**1**	**4**	**3**	**4**	**2**	**4**	**4**	**1**	**2**	**3**	**1**	**3**	**1**	**1**	**1**	**2**	**2**	**2**
Que.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
Ans.	**1**	**3**	**4**	**1**	**3**	**2**	**2**	**1**	**3**	**1**	**2**	**3**	**2**	**4**	**3**	**3**	**3**	**3**	**2**	**3**
Que.	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Ans.	**2**	**3**	**1**	**2**	**2**	**1**	**2**	**2**	**3**	**4**	**3**	**4**	**1**	**1**	**4**	**4**	**4**	**4**	**1**	**4**
Que.	141	142	143																	
Ans.	**2**	**1**	**4**																	

EXERCISE–II

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	**1**	**3**	**4**	**1**	**4**	**3**	**2**	**3**	**4**	**3**	**2**	**2**	**4**	**1**	**2**	**2**	**1**	**3**	**2**	**4**
Que.	21																			
Ans.	**4**																			

EXERCISE–III

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	**2**	**2**	**1**	**3**	**3**	**1**	**4**	**2**	**4**	**4**	**1**	**4**	**4**	**2**	**2**	**2**	**1**	**2**	**3**	**2**
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	**4**	**1**	**2**	**2**	**3**	**2**	**3**	**2**	**4**	**3**	**1**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**3**	**2**
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	**4**	**1**	**2**	**4**	**1**	**4**	**4**	**2**	**3**	**3**	**3**	**1**	**4**	**4**	**1**	**1**	**2**	**2**	**1**	**4**
Que.	61	62	63																	
Ans.	**1**	**1**	**3**																	