XI
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DIGESTION AND ABSORPTION

SYLLABUS

Alimentary canal and digestive glands; Role of digestive enzymes and gastrointestinal hormones; Peristalsis, digestion, absorption and assimilation of proteins, carbohydrates and fats; Calorific value of proteins, carbohydrates and fats; Egestion; Nutritional and digestive disorders – PEM, indigestion, constipation, vomiting, jaundice, diarrhoea.

KEY CONCEPTS

INTRODUCTION

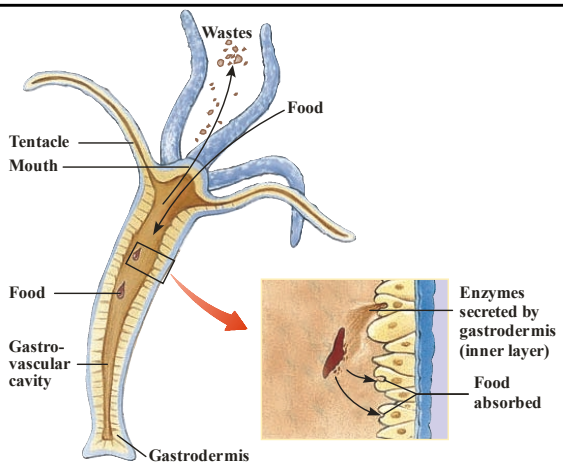
* Process of conversion of complex food substances to simple absorbable forms is called digestion.

Types of digestion in animals

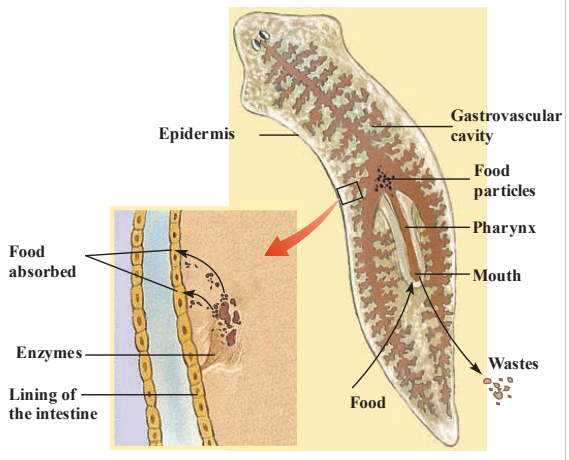
1. **Intracellular only** – no digestive cavity
(i) Cells take in and break down their own food.
(ii) Found in sponges.

2. **Extracellular-**Digestive cavity or tube (true digestive system)
(i) **Mechanical digestion:** may include some type of grinding mechanism (if this occurs, it typically happens first)
(ii) **Chemical digestion** (hydrolysis – breaking polymers by adding water)
- Carbohydrates: amylases
- Proteins: acid digestion, plus proteases
- Lipids: emulsification by bile; lipases

(iii) **Incomplete digestive system :**
- One opening (serves as mouth and anus)
- Gastrovascular cavity with no specialization
- Examples: jellyfish, some flatworms.



(a) Digestive system of a hydra.



(b) Digestive system of a flatworm.

Figure : Simple invertebrate digestive systems (a) Hydras and (b) flatworms (planarians) have a gastrovascular cavity, a digestive tract with a single opening that serves as both mouth and anus.

(iv) Complete digestive system

- Two openings (mouth and anus) with mostly one-way passage of food
- Digestive tract (alimentary canal) typically broken into specialized regions
- Examples: earthworms, vertebrates

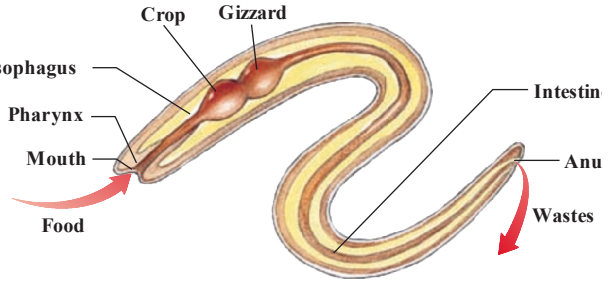


Figure : Digestive tract with two openings. The earthworm, like most animals, has a complete digestive tract extending from mouth to anus. Various regions of the digestive tract are specialize to perform different food-processing functions.

3. **None** – Some parasites absorb food already digested by others (example: tapeworm)

Food sources

(i) **Herbivores** – eat plants (and sometimes photosynthetic protists) exclusively (example: cows); food tougher to digest due to cellulose

(ii) **Carnivores** – eat animals (and sometimes protists and bacteria) exclusively (example: cats) – food typically easier to digest

(iii) **Omnivores** – eat both plants and animals (example: humans) – must have adaptable digestive system

Examples of some adaptations to diet include

(i) **Carnivores**
- (a) have pointed canine teeth for killing
- (b) short incisors for scraping bones
- (c) pointed molars for slicing flesh

(ii) **Herbivores**
- (a) have reduced canine teeth
- (b) sharp incisors for clipping vegetation
- (c) large flat molars and premolars for grinding and crushing vegetation

(iii) **Ruminants :** like deer,cows, and sheep are herbivores and have a specialized part of the stomach called a rumen that helps them digest grass.

(iv) The intestines of herbivores tend to be longer than the intestines of carnivores (meat being rich in protein is more easily digested than plant material).

Digestion in vertebrates

It occurs in the digestive tract or alimentary canal. The various parts involved in digestion can be broadly grouped in two groups -

(i) Digestive tract or alimentary canal

(ii) Digestive glands : On the basis of the embryonic origin, the alimentary canal of vertebrates can be divided into three parts -

(a) **Fore gut / Stomodaeum :** Ectodermal. It includes buccal cavity / oral cavity, pharynx, oesophagus, stomach and small part of duodenum.

(b) **Mid gut / Mesodaeum :** Endodermal. It includes small intestine, and large intestine.

(c) **Hind gut / Proctodaeum :** Ectodermal. It includes anal canal and anus.

DIGESTIVE SYSTEM

* **Function** – Break down food into organic molecules small enough to be used by cells

A. Carbohydrates → monosaccharides (simple sugars) [major energy source]

B. Proteins → amino acids [minor energy source; major building blocks]

C. Lipids → fatty acids and glycerol [major energy source; major building blocks]

D. Also absorbed: various vitamins and minerals, and water.

* **Digestive System involves several functional activities:**

1. **Ingestion-** food intake.

2. **Mastication(chewing)-** Pulverizing & mixing with saliva.

3. **Deglutition-**Swallowing of food

4. **Digestion-**Mechanical & chemical breakdown of food into absorbable molecules.

5. **Absorption-**Passage of food monomers through the mucous membrane of small intestine to blood & lymph

6. **Peristalisis-**Rhythmic wave-like contractions moving food through the digestive tract.
7. **Defecation-**Discharge of indigestable wastes - feces from the body

* **Anatomically** and functionally the digestive system can be divided into a **alimentary canal** (also called **Gastrointestinal tract**) (GI) tract and accessory digestive organs.
  The GI tract which extends from the mouth to the anus is a continuous tube approximately 30 feet (9m) long. It goes through the thoracic cavity and enters the abdominal cavity through the diaphragm.

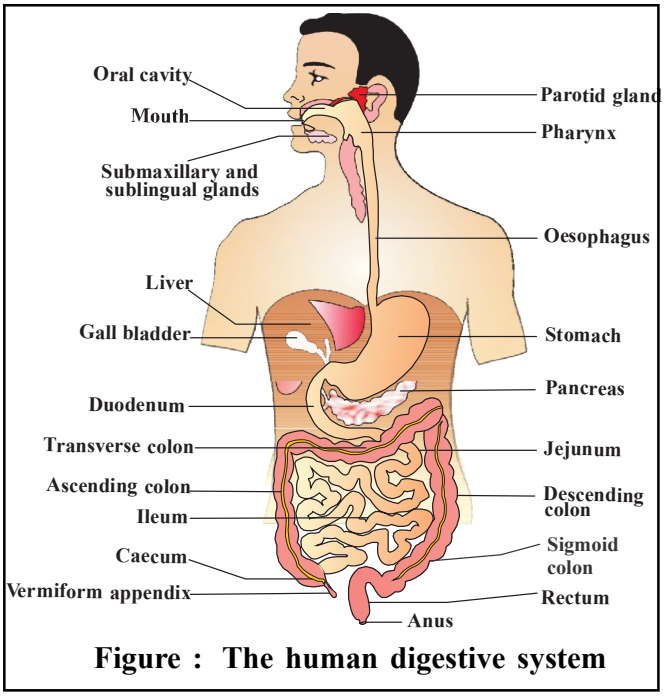


Figure : The human digestive system

* The organs of the digestive system include the oral cavity (mouth), pharynx, oesophagus, stomach, small intestine and large intestine. The accessory organs include teeth, salivary glands, liver, gall bladder and pancreas.

Mouth and Pharynx :

* The mouth leads to the buccal cavity or oral cavity. The oral cavity has a number of teeth and a muscular tongue. Each tooth is embedded in a socket of jaw bone.This type of attachment is called **thecodont**.
* The pharynx, which is posterior to the mouth serves as a common passage way for the respiratory and digestive systems. Both the mouth and the pharynx are lined with non keratinized squamous epithelium that is continuously moistened by saliva.

Cheeks, Lips and Palate :

* The cheeks form the lateral walls of the oral cavity.
* They consist of outer layers of skin, subcutaneous fat and facial muscles that assist in manipulating food in the mouth and inner linings of moistened squamous epithelium.
* The anterior portion of the cheeks terminate in the lips (superior and inferior) that surround the oral orfice.
* The lips are fleshy highly mobile organs whose primary function in humans is associated with speech.
* Each lip is attached from it's inner surface to the gum by a midline fold of mucous membrane called the **labial frenulum.**
* The lips are formed from the obicularis oris muscle and associated connective tissue and are covered with soft pliable skin. Between the outer skin and the mucous membrane there is a transition zone called the **vermillion.**
* Lips are reddish brown to red because they are highly vascular and the blood vessels are close to the surface.
* They also have numerous sensory receptors which aid in determining the temperature and texture of food.
* The palate which forms the roof of the oral cavity consists of the bony **hard palate** and the **soft palate** posteriorly.
* The hard palate is formed by the palatine processes of the maxillae and the horizontal plates of the palatine bones. It is covered by a mucous membrane. Transverse palatine folds or **palatal rugae** are located along the mucous membrane of the hard palate. These serve as friction ridges against which the tongue is placed during swallowing.
* The soft palate is a muscular arch covered by mucous membrane and is continuous with the hard palate anteriorly. Suspended from the middle lower border is a projection called the **palatine uvula**.

* During swallowing the soft palate and the uvula are drawn upward to form a seal and close the **nasopharynx**. This prevents food from entering the nasal cavity

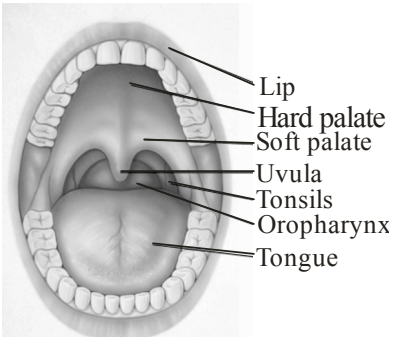


Figure : Oral cavity

Tongue

* The tongue functions to move food around during mastication and in swallowing.
* It is also essential for speech.
* It is a skeletal muscle covered by mucous membrane.
* Extrinsic muscles move the tongue from side to side and in and out.
* The posterior part of the tongue lies in the pharynx and is attached to the hyoid bone.

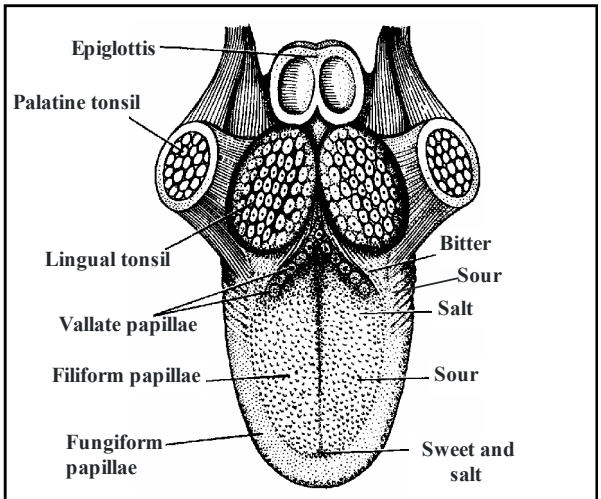


Figure : Locations of papillae and areas of taste on the tongue

* The ventral surface of the tongue is connected to the floor of buccal cavity through a very flexible membrane/ligamentous fold called **frenulum linguae.**
* The surface of the tongue is covered by small elevations called **papillae**.
* This gives the tongue a rough surface that aids in manipulating food.
* Different areas of the tongue have sensory taste receptors (taste buds) that are sensitive to four different tastes. These are sweet (tip of tongue), sour (sides of tongue), bitter (back of tongue) and salty (over most of the tongue but more on the sides).

Teeth:

Morphologically, teeth can be distinguished as homodont or heterodont.

(i) **Homodont :** When all the teeth are structurally and functionally similar. Examples - Vertebrates except metatherian and eutherian mammals.

(ii) **Heterodont :** When the teeth are different in structure and functions. They are distinguished into four types incisors, canines, premolars and molars. Examples - metatherian and eutherian mammals.

(a) **Incisors :** These are the front teeth borne by the premaxillae in upper jaw and tips of dentaries in lower jaw. They are single-rooted monocuspid and long, curved and sharp-edged. They are adapted for cutting or cropping and biting.

(b) **Canines :** There is one pointed canine in each maxillary of upper jaw and each dentary of lower jaw next to the incisors. They are meant for piercing, tearing and offence and defence. They are single rooted and monocuspid.

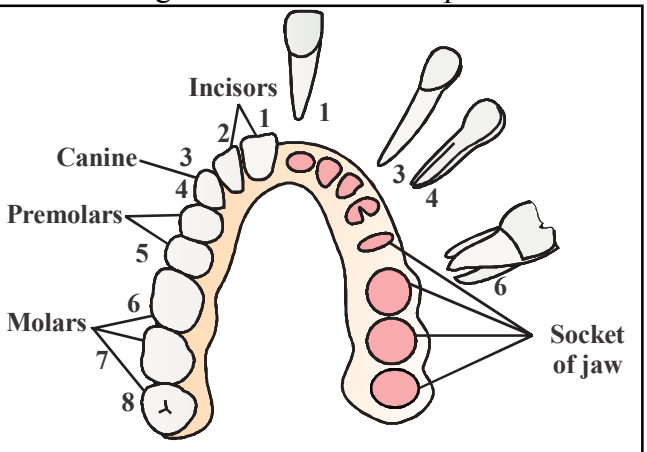


Figure : Arrangement of different types of teeth in the jaws on one side and the socket on the other side.

(c) **Premolars :** They have one root (only in upper first PM two roots) and two cusps (bicuspid).

They are meant for crushing, grinding and chewing.

(d) **Molars :** They have more than two roots (upper molars have three roots and lower molars have two roots) and 4 cuspid.

* Arrangement of teeth in each half of the upper and lower jaw in the order incisors (I), canine (C), premolars (PM) and molars (M) is represented by a dental formula which in human is $\frac{2123}{2123}$. The hard chewing surface of the teeth, made up of enamel, helps in the mastication of food.
* Humans are **diphyodont**;that is we have two sets of teeth in a lifetime.
* Twenty deciduous (milk) teeth erupt beginning at 6 months and ending around 2.5 years.
* Thirty two permanent teeth begin to erupt at around 6 years and continue until around 17.
* The third molars (wisdom teeth) are the last to emerge. Because the human jaw has been getting smaller overall many people have to have these teeth removed because they become impacted or emerge only partially.
* The dental cusps of the upper and lower premolars and molars occlude for chewing food.
* The upper incisors normally form an overbite with the incisors of the lower jaw.
* Masticated food is mixed with saliva containing digestive enzymes.This initiates the digestive process
* The tooth consists of an exposed **crown** supported by a **neck** and anchored firmly in the jaw by a **root.**
* The roots of the teeth fit into sockets (**dental alveoli**) in the alveolar processes of the mandible and maxilla. Each socket is lined with a connective tissue periosteum, the **periodontal membrane**.
* The root of the tooth is covered by a bonelike material called **cementum**.
* Fibers in the periodontal membrane insert into the cementum to fasten the tooth in its dental alveoli.
* The **gingiva** (gum) is the mucous membrane surrounding the alveolar processes in the oral cavity.
* The bulk of the tooth is composed of dentin, a substance similar to bone but harder.
* Covering the dentin on the outside and forming the crown is the **enamel**.
* Enamel is composed primarily of calcium phosphate and is the hardest material in the body.
* The center of the tooth contains the **pulp cavity**.The pulp cavity contains pulp which is composed of connective tissue, blood vessels, lymph vessels and nerves.
* The **root canal**,continuous with the pulp cavity opens to the connective tissue surrounding the root through the **apical foramen**.
* The tooth receives nourishment via the vessels traversing the apical foramen.
* Even though enamel is extremely hard it can be destroyed by bacterial activity (dental caries or tooth decay). These cavities must be filled because new enamel is not produced once teeth erupt.

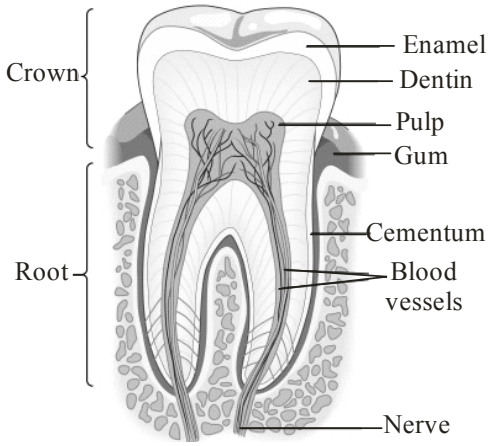


Figure : Structure of tooth

Pharynx

* The funnel shaped pharynx is a muscular tube that contains a passageway about 5 inches long that connects the oral cavity and nasal cavity to the esophagus and larynx.
* The pharynx has both digestive and respiratory functions.
* The supporting walls are skeletal muscle and the inner lining is mucous membrane.
* The pharynx is divided into 3 regions : the **nasopharynx**, posterior to the nasal cavity; the **oropharynx**,posterior to the oral cavity; and the **laryngopharynx**, at the level of the larynx.

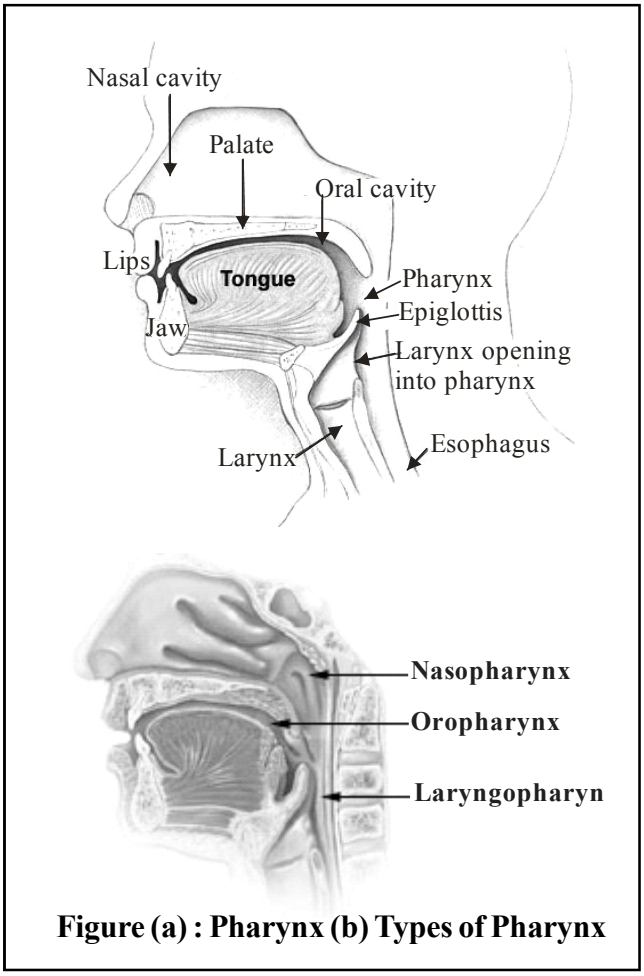


Figure (a) : Pharynx (b) Types of Pharynx

Epiglottis: The epiglottis is a flexible flap at the superior end of the larynx in the throat. It acts as a switch between the larynx and the esophagus to permit air to enter the airway to the lungs and food to pass into the gastrointestinal tract. The epiglottis also protects the body from choking on food that would normally obstruct the airway.

Oesophagus (Oesophagus - British english, Esophagus - American English) :

* The **esophagus** is a muscular tube connecting the pharynx to the stomach that is part of the **upper gastrointestinal tract**.
* It carries swallowed masses of chewed food along its length.
* At the inferior end of the esophagus is a muscular ring called the lower esophageal sphincter or cardiac sphincter.
* The function of this sphincter is to close the end of the esophagus and trap food in the stomach.
* Because this sphincter is not as large or strong as other sphincters of the GI tract backflow can sometimes occur under some conditions. This is what is referred to as heartburn.

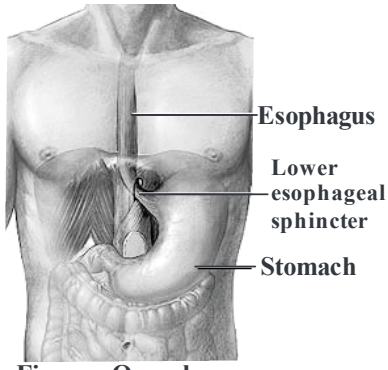


Figure : Oesophagus

* The acidic stomach contents are coming up into the esophagus. During vomiting the contents of the stomach are regurgitated completely to rid the stomach of some perceived toxin or irritant.
* Some mammals have very strong esophageal sphincters. This is the case with rats and mice; which is why they are killed easily by poisoned bait, they cannot regurgitate the poison.

Stomach

* Stomach is located in the upper left quadrant, immediately below the diaphragm. It is a **J** shaped organ that is continuous with the esophagus and empties into the duodenal portion of the small intestine inferiorly.
* In the stomach the food is churned mechanically with gastric secretions to form a pasty substance called **chyme.**
* Once formed it is moved to the small intestine.
* The stomach is divided into four regions: the **cardia**, **fundus**, **body** and **pylorus**.

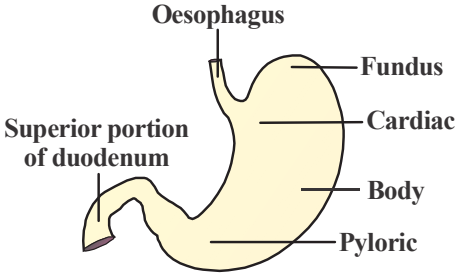


Figure : Anatomical regions of human stomach

* The cardia is the narrow upper region immediately below the lower esophageal sphincter.
* The fundus is the dome shaped portion to the left of and in direct contact with the diaphragm.
* The body is the large central portion and the pylorus is the funnel shaped terminal portion.
* The pyloric sphincter is the modified circular muscle at the end of the pylorus where it joins the small intestine.
* Pylorus in Greek means gatekeeper and the pyloric sphincter acts to regulate the flow of chyme into the small intestine.

Small Intestine :

* Small intestine is distinguishable into three regions, a 'C' shaped **duodenum**, a long coiled middle portion **jejunum** and a highly coiled **ileum**.
* The opening of the stomach into the duodenum is guarded by the pyloric sphincter.
* For the efficient absorption of digested food large surface area is required. Therefore some adaptations are present here.

(i) Great length of the intestine.

(ii) The presence of permanent deep folds in mucosa is called plicae circularis, valvulae conniventae or valves of kerckring.

(iii) Small finger-like foldings called **villi.**

(iv) The cells lining the villi produce numerous microscopic projections called **microvilli** giving a brush border appearance.

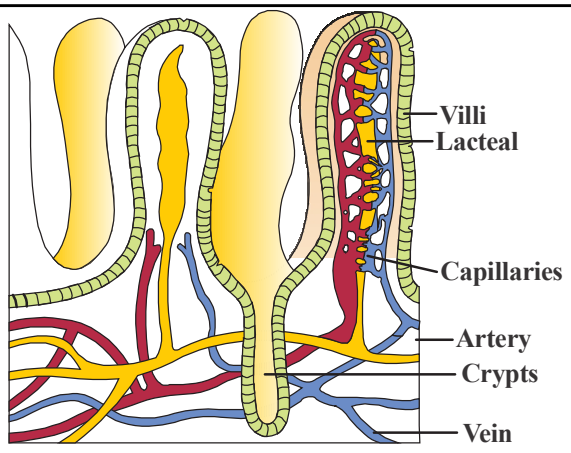


Figure : A section of small intestinal mucosa showing villi

* Villi are supplied with a network of capillaries and a large lymph vessel called the **lacteal.** Mucosal epithelium has goblet cells which secrete mucus that help in lubrication. Mucosa also forms glands in the stomach (gastric glands) and crypts in between the bases of villi in the intestine (crypts of Lieberkuhn).

Large Intestine :

* Ileum opens into the large intestine. It consists of caecum, colon and rectum. **Caecum** is a small blind sac which hosts some symbiotic micro-organisms. A narrow finger-like tubular projection, the vermiform appendix which is a vestigial organ, arises from the caecum.
* The caecum opens into the **colon.**
* The colon is divided into three parts – an ascending, a transverse and a descending part. The descending part opens into the **rectum** which opens out through the anus.

Layers of the Alimentary canal :

* The wall of alimentary canal from oesophagus to rectum possesses four layers namely serosa, muscularis, sub-mucosa and mucosa.

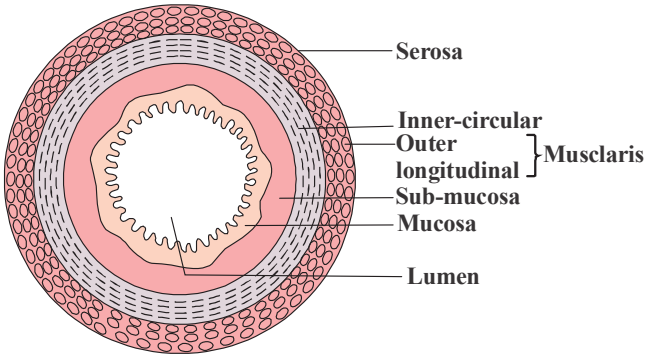


Figure : Diagrammatic representation of transverse section of gut

* **Serosa** is the outermost layer and is made up of a thin mesothelium (epithelium of visceral organs) with some connective tissues.
* **Muscularis** is formed by smooth muscles usually arranged into an inner circular and an outer longitudinal layer. An oblique muscle layer may be present in some regions.
* The **submucosal** layer is formed of loose connective tissues containing nerves, blood and lymph vessels. In duodenum, glands are also present in sub-mucosa.

* The innermost layer lining the lumen of the alimentary canal is the **mucosa**. This layer forms irregular folds (rugae) in the stomach and small finger-like foldings called villi in the small intestine.

DIGESTIVE GLANDS

1. Salivary glands :

* The **salivary glands** are accessory digestive glands that produce a secretion called saliva.
* Saliva functions as a solvent in cleansing teeth and dissolving food molecules so they can be tasted.
* Saliva also contains starch dissolving enzymes (amylase) and lubricating mucous which aids in swallowing. Saliva is secreted continuously in small amounts to keep the mouth moist.
* The amount secreted daily is around 1-1.5 liters.
* The primary production of saliva takes place outside the oral cavity and are transported to the mouth by the salivary ducts.
* The three major pairs of extrinsic salivary glands are the **parotid, submandibular and sublingual glands**.
* The parotid gland is positioned between the ear and the masseter muscle.
* Saliva produced in this gland drains through the parotid duct. It is the parotid gland that becomes swollen and infected with mumps.
* The submandibular gland lies inferior to the body of the mandible, midway along the inner side of the jaw. Saliva produced here empties through the submandibular duct into the floor of the mouth on the lateral side of the lingual frenulum.
* The sublingual gland lies under the mucous membrane of the floor of the mouth.
* This gland has several small submandibular ducts that empty into the floor of the mouth in an area posterior to the papilla of the submandibular duct.
* Two types of secretory cells, serous and mucous, are found in all salivary glands. Serous cells produce a watery secretion containing digestive enzymes and mucous cells produce a thicker, more viscous secretion.

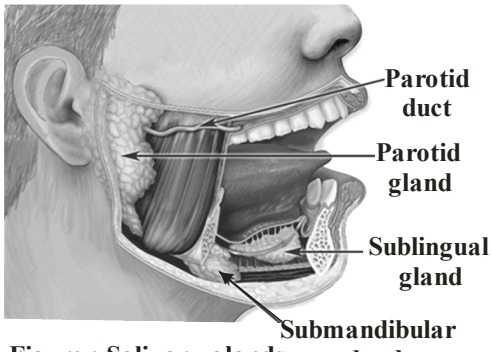


Figure : Salivary glands

* The salivary glands are innervated by both sympathetic and parasympathetic nerves.
* Sympathetic stimulation causes the secretion of small amounts of viscous saliva.
* Parasympathetic stimulation causes the secretion of large amounts of watery saliva. This is responsible for the physiological response to smelling tasty food when you are hungry.

2. Liver :

* Liver is the largest gland of the body weighing about 1.2 to 1.5 kg in an adult human.
* It is situated in the abdominal cavity, just below the diaphragm and has two lobes.
* The hepatic lobules are the structural and functional units of liver containing hepatic cells arranged in the form of cords.

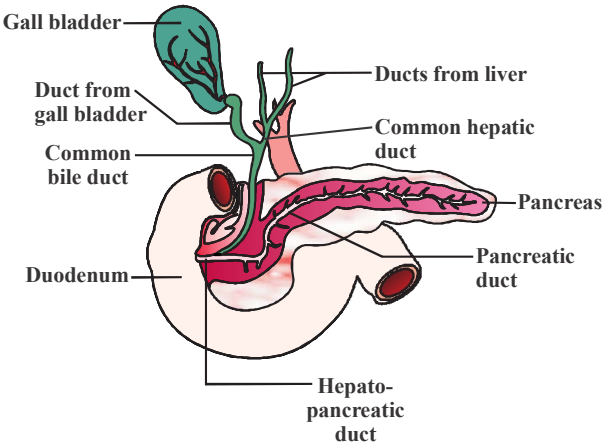


Figure : The duct systems of liver, gall bladder and pancreas

* Each lobule is covered by a thin connective tissue sheath called the **Glisson's capsule.**
* The bile secreted by the hepatic cells passes through the hepatic ducts and is stored and concentrated in a thin muscular sac called the **gall bladder.**

* The duct of gall bladder (cystic duct) along with the hepatic duct from the liver forms the common bile duct.
* The bile duct and the pancreatic duct open together into the duodenum as the common hepato-pancreatic duct which is guarded by a sphincter called the **sphincter of Oddi.**

Functions of the liver

* Regulates glucose concentrations in the blood
* Controls the synthesis and catabolism of fats and proteins.
* Stores glycogen, iron, and vitamins A, D, and B_{12}.
* Filters damaged red blood cells and bacteria from the blood.
* Detoxifies the blood.
* Liver also controls **lipogenesis**. Lipogenesis is the conversion of excess of glucose and amino acids into the fats which also takes place into the liver.
* Liver decomposes the excess and harmful amino . . . . . $_3$ and metabolically useful keto acids by the process of **deamination** in the presence of oxidase enzyme.
* In the liver cells, toxic NH_3 is combined with CO_2 to form less toxic urea by the process of detoxification. Liver also detoxifies the alcohol and converts it into acetaldehyde and then harmless acetyl CoA.
* Liver changes haemoglobin of dead RBCs into bile pigments such as **biliverdin** and **bilirubin** which are egested out along with faeces. Thus, liver helps in **excretion**.
* Liver produces an anticoagulant called **heparin** which prevents the coagulation (clotting of blood) in the blood vessels.
* Liver produces two important proteins : **fibrinogen** and **prothrombin** which help in clotting of blood at injury to check excess of bleeding.
* It also produces protein C, protein S and antithrombin.
* Liver acts as an **erythropocitie organ**. It forms RBCs in the foetus.
* Liver also acts as **haemolytic organ**. It breaks old RBCs.
* **Kupffer's cells** of liver act as phagocytes which eat dead cells and bacteria by the process of **phagocytosis**.
* Liver produces bile.

3. **The pancreas** is a compound (both exocrine and endocrine) elongated organ situated between the limbs of the 'C' shaped duodenum. The exocrine portion secretes an alkaline pancreatic juice containing enzymes and the endocrine portion secretes hormones, insulin and glucagon.

DIGESTION OF FOOD

* The process of digestion is accomplished by mechanical and chemical processes.
* The buccal cavity performs two major functions, mastication of food and facilitation of swallowing.
* The teeth and the tongue with the help of saliva masticate and mix up the food thoroughly.
* Mucus in saliva helps in lubricating and adhering the masticated food particles into a bolus.
* The bolus is then conveyed into the pharynx and then into the oesophagus by swallowing or deglutition.
* The bolus further passes down through the oesophagus by successive waves of muscular contractions called **peristalsis.**
* Waves of peristalsis sweep the bolus through the pharynx and esophagus toward the stomach.
* Circular muscle fibers in the wall of the esophagus contract around the top of the bolus and push it downward. Almost at the same time, longitudinal muscles around the bottom of the bolus and below it contract, which shortens the tube.
* When the body is in an upright position, gravity helps move the food through the esophagus, but gravity is not essential.
* Astronauts eat in its absence, and even if you are standing on your head, food will reach your stomach.

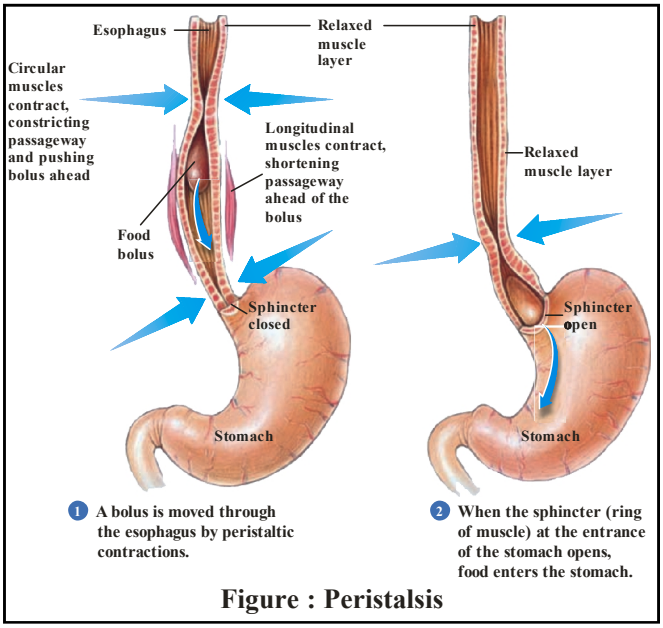


Figure : Peristalsis

* The gastro-oesophageal sphincter controls the passage of food into the stomach.
* The saliva secreted into the oral cavity contains electrolytes (Na^+, K^+, Cl^-, HCO_3^-) and enzymes, salivary amylase and lysozyme.
* The chemical process of digestion is initiated in the oral cavity by the hydrolytic action of the carbohydrate splitting enzyme, the **salivary amylase**.
* About 30 percent of starch is hydrolysed here by this enzyme (optimum pH 6.8) into a disaccharide – maltose.
* **Lysozyme** present in saliva acts as an antibacterial agent that prevents infections.

$$\text{Starch} \xrightarrow[\text{pH 6.8}]{\text{Salivary Amylase}} \text{Maltose}$$

* The mucosa of stomach has gastric glands. Gastric glands have three major types of cells namely -

(i) **Mucus** neck cells which secrete mucus;

(ii) **Peptic** or **chief cells** which secrete the proenzyme pepsinogen; and

(iii) **Parietal or oxyntic cells** which secrete HCl and intrinsic factor (factor essential for absorption of vitamin B_{12}).

* The stomach stores the food for 4-5 hours. The food mixes thoroughly with the acidic gastric juice of the stomach by the churning movements of its muscular wall and is called the chyme.
* The proenzyme pepsinogen, on exposure to hydrochloric acid gets converted into the active enzyme **pepsin**, the proteolytic enzyme of the stomach. Pepsin converts proteins into proteoses and peptones (peptides).
* The mucus and bicarbonates present in the gastric juice play an important role in lubrication and protection of the mucosal epithelium from excoriation by the highly concentrated hydrochloric acid. HCl provides the acidic pH (pH 1.8) optimal for pepsins. **Rennin** is a proteolytic enzyme found in gastric juice of infants which helps in the digestion of milk proteins. Small amounts of lipases are also secreted by gastric glands.
* Various types of movements are generated by the muscularis layer of the small intestine. These movements help in a thorough mixing up of the food with various secretions in the intestine and thereby facilitate digestion.
* The bile, pancreatic juice and the intestinal juice are the secretions released into the small intestine.
* Pancreatic juice and bile are released through the hepato-pancreatic duct. The pancreatic juice contains inactive enzymes – trypsinogen, chymotrypsinogen, procarboxy-peptidases, amylases, lipases and nucleases.
* **Trypsinogen** is activated by an enzyme, enterokinase, secreted by the intestinal mucosa into active trypsin, which in turn activates the other enzymes in the pancreatic juice.
* The **bile** released into the duodenum contains bile pigments (bilirubin and bili-verdin), bile salts, cholesterol and phospholipids but no enzymes.
* Bile helps in emulsification of fats, i.e., breaking down of the fats into very small micelles. Bile also activates lipases.
* The intestinal mucosal epithelium has **goblet cells** which secrete mucus.
* The secretions of the brush border cells of the mucosa alongwith the secretions of the goblet cells constitute the intestinal juice or succus entericus.

This juice contains a variety of enzymes like disaccharidases (e.g., maltase), dipeptidases, lipases, nucleosidases, etc.

* The mucus alongwith the bicarbonates from the pancreas protects the intestinal mucosa from acid as well as provide an alkaline medium (pH 7.8) for enzymatic activities. Sub-mucosal glands (Brunner's glands) also help in this.
* Proteins, proteoses and peptones (partially hydrolysed proteins) in the chyme reaching the intestine are acted upon by the proteolytic enzymes of pancreatic juice as :

$$\left.\begin{matrix}\text{Proteins}\\ \text{Peptones}\\ \text{Proteoses}\end{matrix}\right\} \xrightarrow[\text{Carboxypeptidase}]{\text{Trypsin/Chymotrypsin}} \text{Dipeptides}$$

* Carbohydrates in the chyme are hydrolysed by pancreatic amylase into disaccharides.

$$\text{Polysaccharides (starch)} \xrightarrow{\text{Amylase}} \text{Disaccharides}$$

Fats are broken down by lipases with the help of bile into di-and monoglycerides.

$$\text{Fats} \xrightarrow{\text{Lipases}} \text{Diglycerides} \longrightarrow \text{Monoglycerides}$$

Nucleases in the pancreatic juice acts on nucleic acids to form nucleotides and nucleosides

$$\text{Nucleic acids} \xrightarrow{\text{Nucleases}} \text{Nucleotides} \longrightarrow \text{Nucleosides}$$

The enzymes in the succus entericus act on the end products of the above reactions to form the respective simple absorbable forms. These final steps in digestion occur very close to the mucosal epithelial cells of the intestine.

The breakdown of biomacromolecules occurs in the duodenum region of the small intestine.

$$\text{Dipeptides} \xrightarrow{\text{Dipeptidases}} \text{Amino acids}$$

$$\text{Maltose} \xrightarrow{\text{Maltase}} \text{Glucose} + \text{Glucose}$$

$$\text{Lactose} \xrightarrow{\text{Lactase}} \text{Glucose} + \text{Galactose}$$

$$\text{Sucrose} \xrightarrow{\text{Sucrase}} \text{Glucose} + \text{Fructose}$$

$$\text{Nucleotides} \xrightarrow{\text{Nucleotidases}} \text{Nucleosides} \xrightarrow{\text{Nucleosidases}} \text{Sugars} + \text{Bases}$$

$$\text{Di \& Monoglycerides} \xrightarrow{\text{Lipases}} \text{Fatty acids} + \text{Glycerol}$$

* The simple substances thus formed are absorbed in the jejunum and ileum regions of the small intestine.
* The undigested and unabsorbed substances are passed on to the large intestine.
* No significant digestive activity occurs in the large intestine. The functions of large intestine are:

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

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

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

NEURAL AND HORMONAL REGULATION OF DIGESTION

* The activities of the gastrointestinal tract are coordinated by the nervous system and the endocrine system.
* The nervous system, for example, stimulates salivary and gastric secretions in response to the sight and smell of food.
* When food arrives in the stomach, proteins in the food stimulate the secretion of a stomach hormone called gastrin, which in turn stimulates the secretion of pepsinogen and HCl from the gastric glands.
* The secreted HCl lowers the pH of the gastric juice, which acts to inhibit further secretion of gastrin. Because inhibition of gastrin secretion will reduce the amount of HCl released into the gastric juice, a negative feedback loop is completed. In this way, the secretion of gastric acid is kept under tight control.
* The passage of chyme from the stomach into the duodenum inhibits the contractions of the stomach, so that no additional chyme can enter the duodenum until the previous amount has been processed. This inhibition is mediated by a neural reflex and by a hormone secreted by the small intestine that inhibits gastric emptying.

The hormone is known generically as an **enterogastrone** (entero refers to the intestine; gastro to the stomach).

* The secretion of enterogastrone is stimulated most strongly by the presence of fat in the chyme. Fatty meals therefore remain in the stomach longer than meals low in fat.
* The duodenum secretes two additional hormones. **Cholecystokinin (CCK)**, like enterogastrone, is secreted in response to the presence of fat in the chyme.
* CCK stimulates the contractions of the gallbladder, injecting bile into the duodenum so that fat can be emulsified and more efficiently digested.
* The other duodenal hormone is secretin. Released in response to the acidity of the chyme that arrives in the duodenum, secretin stimulates the pancreas to release bicarbonate, which then neutralizes some of the acidity.
* Secretin has the distinction of being the first hormone ever discovered.

ABSORPTION OF DIGESTED PRODUCTS

* Absorption is the process by which the end products of digestion pass through the intestinal mucosa into the blood or lymph. It is carried out by passive, active or facilitated transport mechanisms.
* Small amounts of monosacharides 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, monosacharides like glucose, electrolytes like Na^+ are absorbed into the blood by this mechanism.
* Fatty acids and glycerol being insoluble, cannot be absorbed into the blood.
* They are first incorporated into small droplets called micelles which move into the intestinal mucosa.
* They are re-formed into very small protein coated fat globules called the chylomicrons which are transported into the lymph vessels (lacteals) in the villi.
* These lymph vessels ultimately release the absorbed substances into the blood stream.
* Absorption of substances takes place in different parts of the alimentary canal, like mouth, stomach, small intestine and large intestine. However, maximum absorption occurs in the small intestine.
* The absorbed substances finally reach the tissues which utilise them for their activities. This process is called assimilation.
* The digestive wastes, solidified into coherent faeces in the rectum initiate a neural reflex causing an urge or desire for its removal. The egestion of faeces to the outside through the anal opening (defaecation) is a voluntary process and is carried out by a mass peristaltic movement.

FOOD ENERGY

* Food contains a number of basic elements such as carbohydrates, proteins,and fats. These elements all produce different quantities of energy when burnt.
* The amount of energy produced when one gram of any of these elements is burned is known as its calorific value.
* The calorific value of each of these food elements is :

Carbohydrate = 4 Calories
Protein = 4 Calories
Fat = 9 Calories

* Fat has a higher calorific value than the same amount of carbohydrates.
* The basal metabolic rate is the amount of energy needed by the body at complete rest to maintain his body functions.
* Carbohydrates are the main source of energy for the human body. When they are broken down they form glucose.

* Glucose is essential as a source of energy and is also important for maintaining tissue protein. The brain and central nervous system depend solely on glucose for their energy requirements.
* Proteins are complex nitrogen-containing compounds that build and repair body tissue.
* They also form antibodies, hemoglobin, enzymes, and hormones.
* The protein that is absorbed through food is used to perform these vital functions, though it may also be used to provide energy to the body, in the absence of sufficient carbohydrates and fats.
* Proteins are made up of amino acids.
* The body's daily requirement of protein is between ten to fifteen per cent of the daily calorie requirement.
* Fats are the most concentrated source of energy in our diet.
* It is important for the absorption of fat-soluble vitamins such as Vitamin A, D, E and K.
* Fats also provide essential fatty acids, which are important for the structure and function of cells. Fat also cushions the vital organs and protects the body from extremes of cold and heat.

ESSENTIAL NUTRIENTS

* Substances that an animal cannot manufacture for itself but which are necessary for its health must be obtained in the diet and are referred to as essential nutrients.
* Included among the essential nutrients are vitamins, certain organic substances required in trace amounts.
* Humans require at least 13 different vitamins.
* Some essential nutrients are required in more than trace amounts. Many vertebrates, for example, are unable to synthesize 1 or more of the 20 amino acids used in making proteins. These essential amino acids must be obtained from proteins in the food they eat. There are nine essential amino acids for humans.
* Food also supplies essential minerals such as calcium, phosphorus, and other inorganic substances, including a wide variety of trace elements such as zinc and molybdenum which are required in very small amounts.

NUTRITIONAL DISORDERS

* For the healthy growth of the individual, a nourishing, well balanced diet is required. A diet has nutrients in the right proportion ensures proper growth and development of both body and mind. If the nutrients are inadequate or not in the right proportion nutritional disorders may occur.

Protein Energy malnutrition (PEM):

Protein energy malnutrition leads to two types of diseases.

1. **Marasmus :** This is due to protein deficiency and not food calories intake. The causal factor may be due to early replacement of mother's milk by other foods of low protein and calorific value. This may happen if the mother has a second pregnancy when the older infant is still too young.

Symptoms :

* As the stored fats and tissue proteins are used up for the production of energy, the infant develops a shrivelled look.
* Ribs become prominent and limbs become very thin as the fat layer beneath the skin disappears.
* Retarded physical and mental growth.
* Severe diarrhoea and other digestive disorders.

Prevention : A protein rich diet such as a combination of wheat, gram, peanut, soyabean and jaggery or a diet with animal protein like mutton, chicken and fish, will help the patient to return back to health.

2. **Kwashiorkor :** Children between 1-3 years of age must consume 1g protein/kg body weight. If they consume below this quantity they can suffer from this protein deficiency disease.

Symptoms :

* Growth is stunted, appetite is poor.
* Stomach gets distended.
* The eyes are bulging.
* The patient develops match stick legs- legs become thin, long and curved.
* Skin may become dark and start peeling off and hair may become dull and loose its lusture.

Prevention : By including food rich in protein into the diet, the disease can be cured.

Wheat, gram, peanut, soyabean and jaggery are recommended.

Anaemia :

* Iron deficiency causes Anaemia.
* Iron is required by the body to form the protein haemoglobin present in the red blood cells in our body.
* The main function of haemoglobin is to transport oxygen from the lungs to the various parts of the body.

Goitre

* Iodine deficiency leads to this disease.
* Iodine is essential for the body in very small quantities for the preparation of thyroid hormone thyroxine.

Xerophthalmia

* This disease is caused by vitamin A deficiency.
* In a mild form this disease causes night blindness.

Rickets

* This disease is caused by vitamin D deficiency.
* Vitamin D is synthesized naturally in the presence of sunlight.

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.

CONCEPT REVIEW

* The process of nutrition in man is holozoic. In this type of nutrition, the nutrients are made available to the body through digestion of food.
* During digestion, four different groups of molecules are commonly encountered. Each is broken down into its molecular components by specific enzymes, as follows:

(a) Starches are broken down into glucose molecules.
(b) Proteins are broken down into amino acids.
(c) Fats (or lipids) are broken down into glycerol and fatty acids.
(d) Nucleic acids are broken down into nucleotides.

* **Layers of the wall**
  - Mucous membrane – involved in secretion, absorption, and protection
  - Submucosa – provides nutrients for the other layers via blood vessels; contains nerves and lymphatic vessels
  - Muscular layer – mixes and moves the contents of that section of the tube
  - Serous layer – lubricates the organs and reduces friction
* Peristalsis – alternate waves of contraction and relaxation that propel the contents of that tube forward.
* **Types of teeth**
  - Incisors (8) – used for biting
  - Canines (4) – used for grasping and tearing
  - Bicuspids (8) – used for grinding and crushing
  - Molars (12) – for grinding only
* **Composition of Saliva**
  - Mostly water
  - pH = 6.2 – 7.4
  - Hypotonic to plasma.
  - Salivary amylase – enzyme that begins starch digestion in the mouth
  - Lingual lipase – enzyme that digests fat
  - Mucus – binds food and lubricates it
  - Immunoglobulin A (IgA) – antibody that inhibits bacterial growth
  - Electrolytes – including sodium, potassium, chloride, phosphate, and bicarbonate ions

* The stomach mixes the food with water and gastric juice to produce a creamy medium called chyme.
* The stomach contents are extremely acidic, with a pH between 1.5 and 2.5.
* Movement of chyme into the small intestine is regulated by a valve at the end of the stomach, the pyloric sphincter.
* **Regions of the stomach**
- Cardiac – area adjacent to the opening from the esophagus
- Fundic – superior-most section
- Body – the main part of the stomach
- Pyloric – muscular section that pushes the stomach contents into the small intestine
* **Microscopic anatomy of the stomach**
- Mucosa – simple columnar epithelium
- Gastric pits – cells at the base of the gastric pits divide and produce new epithelial cells
- **Glandular cells**
  – Mucous cells – secrete mucus
  – Parietal cells - secrete hydrochloric acid and intrinsic factor.
  – Chief cells – secrete pepsinogen
- **Gastric secretions**

  Hydrochloric acid – makes the stomach acidic
  – Activates pepsin
  – Denatures proteins
  – Destroys microorganisms
  – Pepsin – enzyme that splits proteins
  – Intrinsic factor – aids in the absorption of vitamin B_{12}.
* The wall of the small intestine is the source of various enzymes, including proteolytic enzymes (or proteases, enzymes that digest proteins, such as amino peptidase), maltase and lactase (for the digestion of disaccharides), and phosphatases (for the digestion of nucleotides).
* The pancreas produces various enzymes, including trypsin and chymotrypsin (proteases), lipase (digestion of fats), and pancreatic amylase (digestion of starch). These and other enzymes, packaged in an alkaline solution that serves to neutralize the HCl in the chyme, enter the duodenum through the pancreatic duct.
* Hepatic lobule – the smallest functional unit of the liver
* The Gallbladder – stores and concentrates bile between meals.
* The Pancreas Secrete enzymes that breakdown carbohydrates, fats, proteins, and nucleic acids.
* Villi – finger-like projections that increase the surface area for nutrient absorption
* Microvilli – microscopic finger-like projections on the surface of epithelial cells
* Plicae circulares – deep permanent folds of the mucosa
- Increase surface area
- Slows down the movement of chyme
* Gastrin is produced by cells in the stomach lining when food reaches the stomach or when the nervous system, through smell or sight, senses the availability of food. Gastrin enters the blood stream and stimulates other cells of the stomach to produce gastric juices.
* Secretin is produced by the cells lining the duodenum when food enters. Secretin stimulates the pancreas to produce bicarbonate which, when deposited into the small intestine, neutralizes the acidity of the chyme.
* Cholecystokinin is produced by the small intestine in response to the presence of fats. Cholecystokinin stimulates the gallbladder to release bile and the pancreas to release its enzymes.
* **Absorption of vitamins :** Water-soluble vitamins like members of B complex (except B_{12}) and vitamin C readily diffuse across the walls of the intestine into the blood. The fat-soluble vitamins A, D, E and K are dissolved in micelles, which enter the mucosal cells of the intestine, by simple diffusion. The absorption of these fat-soluble vitamins is markedly decreased in the absence of bile.
* Pepsin = Stomach
  Trypsin = Intestine
  Ptyalin = Mouth
* pH of saliva is 6.5.
* Glycogen of liver is principal source of blood sugar.
* Energy in kcal/g of carbohydrate, protein and fat is in the ratio of 1 : 1 : 2.
* Pancreatic amylase digests polysaccharides into disaccharides.

Disaccharidases such as maltase, lactase, sucrase, etc., further digest the disaccharides.

* **Action of bile juice :**
Bile juice has bile salts such as bilirubin and biliverdin which break down large, fat globules into smaller globules so that pancreatic enzymes can easily act on them. This process is known as emulsification of fats. Bile juice also makes the medium alkaline and activates lipase. Lipase then breaks down fats into diglycerides and monoglycerides.
* Goblet cells are located in the intestinal mucosal epithelium and secrete mucus.
* Fats are broken down into di- and monoglycerides with the help of lipases.
* Gastric glands of stomach mucosa have oxyntic cell which secrete HCl.
* Saliva contains enzymes that digest starch.
* Sphincter of ani interus = Guarding of terminal part of alimentary canal.
Cardiac sphincter = Between oesophagus and anterior stomach.
Sphincter of Oddi= Opening of hepatopancreatic duct into duodenum.
Ileocaecal sphincter = Between small intestine and bowel.
Pyloric sphincter = Between duodenum and posterior stomach.
* **Dental formula :**

(a) Temporary teeth in man $= \frac{2102}{2102} = \frac{5}{5} \times 2 = 20$

(b) Teeth at the age of 20 year

$$= \frac{2122}{2122} = \frac{7}{7} \times 2 = 28$$

(c) Human beings (Adult) $\frac{2123}{2123} = \frac{8}{8} \times 2 = 32$

(d) Rabbit $= \frac{2033}{1023} = \frac{8}{6} \times 2 = 28$

(e) Elephant $= \frac{1003}{0003} = \frac{4}{3} \times 2 = 14$

(f) Rat $= \frac{1003}{1003} = \frac{4}{4} \times 2 = 16$

* **Polyphyodont** dentition involves replacement of teeth from time to time several times in lifetime so that jaws are never left without teeth. Lower vertebrates having loose attachment of teeth lose teeth while feeding and capturing prey and hence teeth must grow again to replace the lost ones.
* **Diphyodont** dentition is a characteristic of mammals in which milk teeth appear in the young ones but as they grow and jaw becomes larger, milk teeth are replaced by larger permanent ones to fit in the larger jaw bone.
* **Monophyodont** teeth appear only once in lifetime and if they fall they are never again replaced by the new ones. Toothless animals have this kind of teeth and marsupials retain their milk teeth.
* Based on the type of attachment of teeth on the jaw bone the following three types are found in vertebrates:
  - **Acrodont** teeth are attached on the top surface of the jaw bone as in fish and amphibians. This type of attachment is not very strong and teeth are lost easily and are replaced by new ones.
  - **Pleurodont** teeth are attached on the inner side and uppper side of the jawbone that brings larger surface area of tooth in contact with jawbone and hence attachment is stronger, as in lizards and urodeles. But this attachment is also not as strong as thecodont.
  - **Thecodont** dentition is found in mammals in which root of the tooth is firmly fixed in a socket of the jawbone, making the attachment strongest in vertebrates. This is a peg and socket attachment with the help of cementum that surrounds the root portion of the tooth.
* Based on the kinds of teeth found there are two types of dentition:
  - **Homodont** dentition is found in the majority of vertebrates such as fish, amphibia and reptiles in which all teeth are functionally and anatomically of the same type, although their size may be variable depending on the location. Sometimes functionally some teeth may be specialized as fangs of snakes.

- **Heterodont** dentition occurs in mammals in which there are 4 functionally different types of teeth, namely, flat incisors for cutting, long and pointed canines for tearing flesh and large and broad premolars and molars with flat grinding surface. Molars have no counterparts in the milk teeth.

* **Basal metabolic rate (BMR)** is the amount of energy expended while at rest in a neutrally temperate environment, in the post-absorptive state (meaning that the digestive system is inactive, which requires about twelve hours of fasting).
* Metabolic rate increases as weight, height, and surface area increase. Body composition: Fat tissue has a lower metabolic activity than muscle tissue.
* Insectivore : Short intestine,no cecum.
* Nonruminant herbivore : Simple stomach, large cecum
* Ruminant herbivore : Four-chambered stomach with large rumen;long small and large intestine
* Carnivore : Short intestine and colon,small cecum.

IMPORTANT POINTS

* **Digestion of triglyceride**

Triglyceride
↓ Lipase
1,2-Diglyceride + Fatty acid
↓ Lipase
2-Monoglyceride + Fatty acid
↓ Isomerisation
1-Monoglyceride

Glycerol + Fatty acid

* **Differences between Jejunum and Ileum :**

Feature	Jejunum	Ileum
Location	Occupies upper and left part of the intestinal area,	Occupies lower and right part of intestinal area.
Length and breadth	About 2.4 m and about 4 cm wide.	About 3.6m long and about 3.5 cm wide.
Walls	Thicker and more vascular.	Thinner and less vascular.

* **Table : Summary of Digestion**

	Carbohydrates	Proteins	Lipids
Mouth	Polysaccharides ↓ Salivary amylase Maltose and small polysaccharides		
Stomach	Action continues until acidic pH inactivates salivary amylase.	Protein ↓ Pepsin Short polypeptides	
Small intestine	Undigested polysaccharides ↓ Pancreatic amylase Maltose and other disaccharides ↓ Maltase, sucrase, lactase Monosaccharides	Polypeptides ↓ Trypsin, chymotrypsin Small polypeptides and peptides ↓ Carboxypeptidase, Peptidases, Dipeptidases Amino acids	Glob of fat ↓ Bile salts Emulsified fat droplets ↓ Pancreatic lipase Fatty acids and glycerol

* **Table : Some hormones that regulate digestion :**

Hormone	Source	Target tissue	Actions	Factors that stimulates release
Gastrin	Stomach (mucosa)	Stomach (gastric glands)	Stimulates gastric glands to secrete pepsinogen.	Distention of the stomach by food; certain substances such as partially digested proteins and caffeine.
Secretin	Duodenum (mucosa)	Pancreas Liver	Signals secretion of sodium bicarbonate Stimulates bile secretion	Acidic chyme acting on mucosa of duodenum.
Cholecystokinin (CCK)	Duodenum (mucosa)	Pancreas Gallbladder	Stimulates release of digestive enzymes. Stimulates emptying of bile.	Presence of fatty acids and partially digested proteins in duodenum
Gastric inhibitory peptide (GIP)	Duodenum (mucosa)	Stomach	Decreases stomach churning, thus slowing emptying	Presence of fatty acids or glucose in duodenum

* **Table : Differences between Small Intestine and Large Intestines.**

Feature	Small Intestine	Large Intestine
1. Size	Longer (about 6 metres) but narrower than large intestine.	Shorter (about 1.5 metres) but wider than small intestine.
2. Division	it is divisible into duodenum, jejunum and ileum.	It is divisible into caecum, colon and rectum.
3. Fixity	Greater part of small intestine is freely movable.	Greater part of large intestine is fixed.
4. Sacculations	Absent.	Present
5. Taeniae coli	Absent.	Present
6. Villi	Present	Absent
7. Peyer's patches	Present in ileum	Absent
8. Digestion and absorption	Completes digestion and absorption of digestion products. Also produces some hormones.	Absorbs water, forms and eliminates faces. Vitamin B and K are produced by bacterial activity.
9. Effects of infection and irritation	Mucosal irritation due to infection causes diarrhoea.	Mucosal irritation due to infection causes dysentery.
10. Common site for	(a) Intestinal worms, (b) Typhoid and (c) Tuberculosis	(a) *Entamoeba histolytica* (b) Dysentery organisms. (c) Carcinoma.

* **Table : Layers of the Wall of the Alimentary Canal**

Layer	Composition	Function
Mucosa	Epithelium, connective tissue, smooth muscle.	Protection, secretion, absorption.
Submucosa	Loose connective tissue, blood vessels, lymphatic vessels, nerves.	Nourishes surrounding tissues, transports absorbed materials.
Muscular layer	Smooth muscle fibers arranged in circular and longitudinal groups.	Movements of the tube and its contents.
Serosa	Epithelium, connective tissue.	Protection, lubrication

* **Table : The major salivary glands**

Gland	Location	Duct	Types of Secretion
Parotid glands	Anterior to and somewhat inferior to the ears between the skin of the cheeks and the masseter muscles.	Parotid ducts pass through the buccinator muscles and enter the mouth opposite the upper second molars.	Clear, watery serous fluid, rich in salivary amylase.
Submandibular glands	In the floor of the mouth on the inside surface of the mandible.	Ducts open inferior to the tongue near the frenulum.	Some serous fluid with some mucus; more viscous than parotid secretion.
Sublingual glands	In the floor of the mouth inferior to the tongue.	Many separate ducts.	Primarily thick, stringy mucus.

* **Table : Major Components of Gastric Juice**

Component	Source	Function
Pepsinogen	Chief cells of the gastric glands.	Inactive form of pepsin.
Pepsin	Formed from pepsinogen in the presence of hydrochloric acid.	A protein-splitting enzyme that digests nearly all types of dietary protein.
Hydrochloric acid	Parietal cells of the gastric glands.	Provides the acid environment needed for production and action of pepsin.
Mucus	Goblet cells and mucous glands.	Provides a viscous, alkaline protective layer on the inside stomach wall.
Intrinsic factor	Parietal cells of the gastric glands.	Aids in vitamin B_{12} absorption.

* **Table : Function of Digestive secretions**

Fluid or Enzyme	Source	Function
Mouth		
Saliva	Salivary glands	Moistens and lubricates food
Salivary amylase	Salivary glands	Digests starch
Stomach		
Hydrochloric acid	Gastric glands	Kills bacteria, activates pepsin
Pepsinogen	Gastric glands	Active form, pepsin, digests protein
Mucus	Mucous cells	Protects stomach lining
Intrinsic factor	Gastric glands	Binds to vitamin B_{12}, aiding in its absorption
Gastrin	Gastric glands	Increases stomach secretions
Small Intestine and Associated Glands		
Bile salts	Liver	Emulsify fats
Bicarbonate ions	Pancreas	Neutralize stomach acid
Trypsin, chymotrypsin	Pancreas	Digest protein
Pancreatic amylase	Pancreas	Digests starch
Pancreatic lipase	Pancreas	Digests lipid
Nucleases	Pancreas	Digest nucleic acid
Mucus	Duodenal glands and goblet cells	Protects duodenum from stomach acid and digestive enzymes
Secretin	Duodenum	Inhibits gastric secretions Stimulates sodium bicarbonate secretion from the pancreas and bile secretion from the liver
Cholecystokinin	Duodenum	Inhibits gastric secretion, stimulates gallbladder contraction and pancreas secretion (enzymes)
Gastric inhibitory polypeptide	Duodenum	Inhibits gastric motility & secretion,stimulates gallbladder contraction
Peptidases	Small intestine	Digest polypeptide
Amylase	Small intestine	Digests starch
Lipase	Small intestine	Digests lipid
Sucrase	Small intestine	Digests sucrose
Lactase	Small intestine	Digests lactose
Maltase	Small intestine	Digests maltose

* **Table : Summary of the Major Digestive Enzymes**

Enzyme	Source	Digestive action
Salivary Enzyme		
Salivary amylase	Salivary glands	Begins carbohydrate digestion by breaking down starch and glycogen to disaccharides.
Gastric Enzymes		
Pepsin	Gastric glands	Begins protein digestion
Gastric lipase	Gastric glands	Begins butterfat digestion
Pancreatic Enzymes		
Pancreatic amylase	Pancreas	Breaks down starch and glycogen into disaccharides.
Pancreatic lipase	Pancreas	Breaks down fats into fatty acids and glycerol.
Trypsin, chymotrypsin	Pancreas	Breaks down proteins or partially digested proteins into peptides.
Carboxypeptidase	Pancreas	Breaks down peptides into amino acids.
Nucleases	Pancreas	Breaks down nucleic acids into nucleotides.
Intestinal Enzymes		
Peptidase	Mucosal cells	Breaks down peptides into amino acids.
Sucrase, maltase, lactase	Mucosal cells	Breaks down disaccharides into monosaccharides.
Intestinal lipase	Mucosal cells	Breaks down fats into fatty acids and glycerol.
Enterokinase	Mucosal cells	Shortens trypsinogen into trypsin.

QUESTION BANK

EXERCISE - 1 (LEVEL-1) [NCERT EXTRACT]

SECTION - 1 (VOCABULARY BUILDER)

Choose one correct response for each question.

For Q.1-Q.6

Match the column I with column II.

Q.1

	Column I	Column II
(a)	Cardiac sphincter	(i) Hepatopancreatic duct
(b)	Pyloric sphincter	(ii) Joins gall bladder to common bile duct.
(c)	Sphincter of oddi	(iii) Opening of stomach into duodenum.
(d)	Cystic ducts	(iv) Opening of oesophagus into stomach

Codes

(A) a-iv, b-iii, c-i, d-ii (B) a-iv, b-iii, c-ii, d-i

(C) a-iii, b-iv, c-i, d-ii (D) a-ii, b-iv, c-i, d-iii

Q.2

	Column I	Column II
(a)	Salivary amylase	(i) converts proteins to peptides (several amino acids)
(b)	Pepsin	(ii) converts starch to smaller polysaccharides (many sugar molecules attached together).
(c)	Gastric lipase	(iii) converts fats to fatty acids and glycerol.
(d)	Chymo-trypsin	(iv) converts polypeptides (long chains of amino acids) to peptides.

(A) a-i, b-ii, c-iii, d-iv (B) a-ii, b-i, c-iii, d-iv

(C) a-iii, b-i, c-iv, d-ii (D) a-ii, b-iv, c-i, d-iii

Q.3

	Column I	Column II
(a)	Bilirubin and biliverdin	(i) Parotid
(b)	Hydrolysis of starch	(ii) Bile
(c)	Digestion of fat	(iii) Lipases
(d)	Salivary gland	(iv) Amylases

(A) a-ii, b-iv, c-iii, d-i (B) a-iv, b-iii, c-ii, d-i

(C) a-iii, b-i, c-iv, d-ii (D) a-ii, b-iv, c-i, d-iii

Q.4

	Column I	Column II
(a)	Lactase	(i) converts sucrose to glucose and fructose.
(b)	Maltase	(ii) converts maltose to glucose.
(c)	Sucrase	(iii) converts lactose to glucose and galactose.
(d)	Nuclease	(iv) converts nucleic acids to nucleotides.

(A) a-iii, b-ii, c-i, d-iv (B) a-iv, b-iii, c-ii, d-i

(C) a-iii, b-i, c-iv, d-ii (D) a-ii, b-iv, c-i, d-iii

Q.5

	Column I	Column II
(a)	Bile	(i) emulsifies fats-breaks large fat globules into smaller globules.
(b)	Saliva	(ii) moistens food and contains salivary amylase which begins the digestion of starch.
(c)	Enzymes	(iii) bring about the breakdown of carbohydrates, fats, and proteins to simple sugars, fatty acids, glycerol, and amino acids.
(d)	Hydrochloric acid	(iv) helps in breakdown food in the stomach and dissolves hard materials like bone.

(A) a-i, b-ii, c-iv, d-iii (B) a-i, b-ii, c-iii, d-iv

(C) a-iii, b-i, c-iv, d-ii (D) a-ii, b-iv, c-i, d-iii

Q.6

Column-I	Column-II
(a) Biomacromolecules of food	(i) Alimentary canal and associated gland
(b) Human digestive system	(ii) Embedded in jawbones.
(c) Stomach	(iii) Outer wall of visceral
(d) Thecodont	(iv) Converted into simple substances
(e) Serosa	(v) J-shaped bag like structure

(A) a-ii, b-i, c-v, d-iii, e-iv
(B) a-iv, b-i, c-v, d-ii, e-iii
(C) a-i, b-ii, c-iii, d-iv, e-v
(D) a-i, b-iii, c-ii, d-iv, e-v

SECTION - 2 (BASIC CONCEPTS BUILDER)

For Q.7 to Q.40 :

Choose one word for the given statement from the list.

Molecule; intracellular; salivary glands; esophagus; 3; Gastric; HCl; pepsinogen; rectum;acidicity; mucus; pyloric; small intestine; mouth; teeth; liver; mucosa; digestion; absorption; ileocecal; colon or large intestine; pancreas; water; feces; anus, breakdown; smaller; absorbed; stomach;enzymatic hydrolysis; specific; bond; gastroesophageal; extracellular.

PART-A

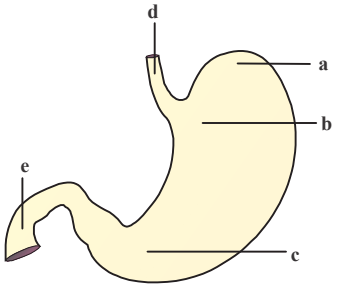
Digestion begins in the (7) ____. The mechanical processing begins with the action of the (8) _____ and the secretions from the ____(9)___ . The processed food now quickly passes through the (10) _____ and through the (11) _____ sphincter into the (12) ____. Additional mixing occurs in the stomach due to the (13) __ layers of smooth muscle. (14) ___ secretions are added that contain (15) ____ and (16) ____, which is inactive and becomes activated due to the (17) ___ of the stomach. In addition, there is a large amount of (18) ___ added for lubrication and protection. The chyme now passes through the (19) ___ sphincter and enters the (20) ____. Here secretions from the (21) ____ and (22) ____ are added. In addition, the intestinal (23) ____ secretes both mucus and enzymes. The majority of (24) ____ and (25) ___ occurs in the small intestine. The remaining chyme will pass through the (26) ___ sphincter and enter the (27) ___. The primary function in this area is absorption of (28) ____ and bile salts. The final portion of the digestive system is the (29) _____. (30) ____, residual undigested/absorbed material, will exit the body via the (31) ____.

PART-B

Digestion is the (32) ___ of larger particles into (33) ____ particles that can be (34)____ into body fluids and cells. Many of the chemical bonds of larger particles are broken by (35) _____. These enzymatic reactions are often very (36) _____. There is a separate enzyme for each type of (37) _____ or (38) ____. These digestive processes can be (39) ___ or (40) ____.

SECTION - 3 (ENHANCE DIAGRAM SKILLS)

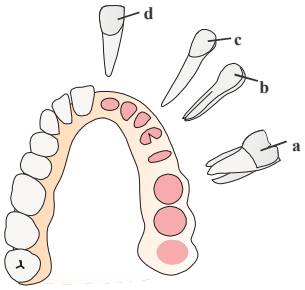
Q.41 What is the correct labelling of the diagram :



(A) a-Fundic portion, b-Cardiac region, c-Pyloric region, d-Food pipe, e-Wind pipe
(B) a-Fundus, b-Pyloric region, c-Cardiac region, d-Oesophagus, e-Duodenum
(C) a-Fundic region, b-cardiac region, c-Pyloric region, d-Oesophagus, e-Duodenum

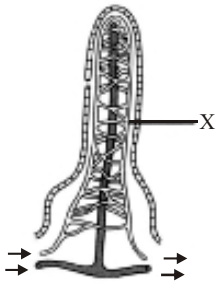
(D) a-Cardiac region, b-Pyloric region, c-Fundic region, d-Oesophagus, e-Duodenum

Q.42 The given schematic diagram diepicts heterodont teeth and its thecodont arrangement. Find the correct labelling for a-d.



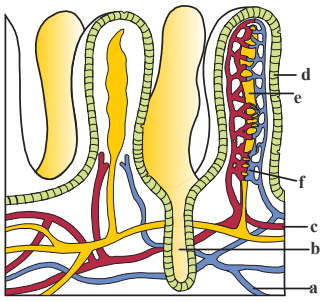
(A) a-Incisor, b-Canine, c-Premolar, d-Molar
(B) a-Molar, b-Premolar, c-Canine, d-Incisor
(C) a-Incisors, b-Premolar, c-Canine, d-Molar
(D) a-Molar, b-Premolar, c-Incisor, d-Canine

Q.43 The diagram shows a section through a villus.



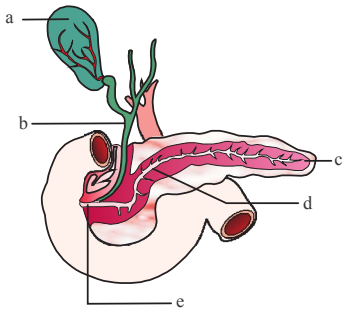
What substance does structure X transport?
(A) Amino acids (B) Blood
(C) Fats (D) Starch

Q.44 Choose the correct labelling of transverse section of mucosa of small intestine –



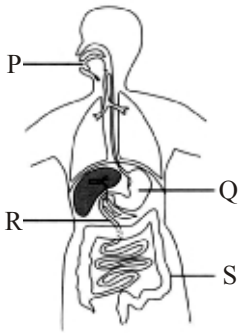
(A) a-Vein, b-Crypt, c-Artery, d-Villi, e-Lacteal, f-Capillaries
(B) a-Artery, b-Crypt, c-Vein, d-Villi, e-Capillaries, f-Lacteal
(C) a-Vein, b-Artery, c-Crypt, d-Villi, e-Capillaries, f-Lacteal
(D) a-Villi, b-Lacteal, c-Capillaries, d-Artery, e-Crypt, f-Vein

Q.45 Choose the correct labelling for a duct system of pancreas, liver and gall bladder.



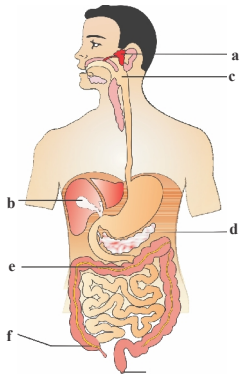
(A) a-Gall bladder, b-Common bile duct, c-Hepato-pancreatic duct, d-Pancreas, e-Pancreatic duct
(B) a-Gall bladder, b-Bile duct, c-Hepato pancreatic duct, d-Pancreatic duct, e-Pancreas
(C) a-Gall bladder, b-Bile duct, c-Pancreatic duct, d-Pancreas, e-Hepato pancreatic duct
(D) a-Gall bladder, b-Common bile duct, c-Pancreas, d-Pancreatic duct, e-Hepato pancreatic duct

Q.46 The diagram shows the human alimentary canal.



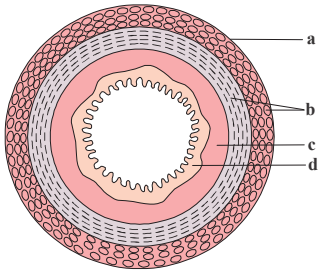
In which parts is food digested by the action of protease?
(A) P and Q (B) Q and R
(C) Q and S (D) R and S

Q.47 Choose the correct labelling for digestive system in humans.



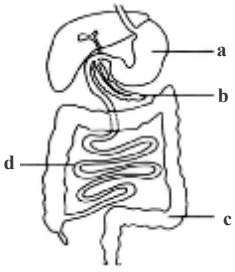
(A) a-Parotid gland, b-Liver, c-Larynx, d-Pancreas, e-Transverse colon, f-Caecum
(B) a-Parotid gland, b-Gall bladder, c-Pharynx, d-Pancreas, e-Transverse colon, f-Caecum
(C) a-Parotid gland, b-Liver, c-Pharynx, d-Pancreas, e-Ascending colon, f-Caecum
(D) a-Parotid gland, b-Gall bladder, c-Thymus, d-Pancreas, e-Ascending colon, f-Caecum

Q.48 Choose the correct labelling for alimentary canal–



(A) a-Muscularis; b-Serosa; c-Submucosa; d-Mucosa
(B) a-Muscularis; b-Serosa; c-Mucosa; d-Submucosa
(C) a-Serosa; b-Muscularis; c-Mucosa; d-Submucosa
(D) a-Serosa; b-Muscularis; c-Submucosa; d-Mucosa

For Q. 49 and Q.50 :
Diagram shows part of the human alimentary canal.



Q.49 In which labelled region does the digestion of protein begin?
(A) a (B) b
(C) c (D) d

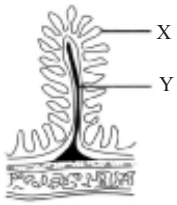
Q.50 In which labelled region does most absorption occur?
(A) a (B) b
(C) c (D) d

For questions 51 and 52
Refer to the diagram below which shows a section of the human digestive tract.

Q.51 Which of the following structures secretes bile into the small intestines?
(A) J (B) L
(C) M (D) N

Q.52 Which of the following structures is/are involved in the enzymatic digestion of fats?
(A) N only (B) M and N only
(C) J and N only (D) J and L only

For questions 53 and 54
Refer to the diagram below which shows a section of the intestinal villus.

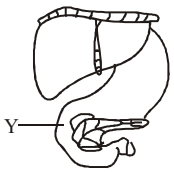


Q.53 Which of the following descriptions of the cells of X is correct?
(A) They have thin cell walls to facilitate efficient absorption.
(B) They secrete amylase to help digestion of starch.
(C) They secrete hydrochloric acid to kill bacteria.
(D) They secrete protease to help digestion of proteins.

Q.54 Which of the following substances is absorbed into structure Y?

(A) Fats (B) Fatty acids
(C) Glucose (D) Vitamin

Q.55 What is structure Y?



(A) Duodenum (B) Ileum
(C) Gall bladder (D) Pyloric sphincter

SECTION - 4 (ENHANCE PROBLEM SOLVING SKILLS)

Choose one correct response for each question.

PART - 1 : DIGESTIVE SYSTEM

Q.56 Which of the following is/are the major components of food?

(A) Proteins (B) Cereals
(C) Fats & it derivatives (D) All of these

Q.57 In man, the gall bladder is situated in _____ lobe of liver.

(A) left (B) right
(C) caudate (D) quadrate

Q.58 Which is the largest gland of human body?

(A) Gastric gland (B) Pancreas
(C) Liver (D) Salivary gland

Q.59 The surface area of the small intestine is increased by –

(A) folds in its wall (B) villi
(C) microvilli (D) all of these

Q.60 Which one serves as a passage for both food and air?

(A) Larynx (B) Pharynx
(C) Gullet (D) Glottis

Q.61 Name that part of small intestine in which the pyloric region of stomach opens.

(A) duodenum (B) ileum
(C) jejunum (D) None of the above

Q.62 Which of the following correctly depicts the dental formula of a child?

(A) $\frac{2112}{2112}$ (B) $\frac{2120}{2120}$
(C) $\frac{2123}{2123}$ (D) $\frac{2111}{2111}$

Q.63 What is frenulum?

(A) It is the fold by which tongue is attached to the floor of oral cavity.
(B) It is an adenoid which is present on pharyngeal wall.
(C) It is a tonsil like structure on the lateral walls of palate.
(D) It is a V-shaped furrow which divides the surface of tongue.

Q.64 In which layer of stomach are gastric glands located?

(A) Serosa (B) Mucosa
(C) Submucosa (D) Muscularis mucosa

Q.65 What do you mean by the process of digestion?

(A) Conversion of complex substances into simpler form.
(B) Absortion of monomers by the body.
(C) Conversion of monomers into polymers.
(D) Absorption of water and food.

Q.66 The lining of intestinal wall from outside to inside is made up of

(A) circular muscles → longitudinal muscles → mucosa → submucosa
(B) longitudinal muscles → circular muscles → submucosa → mucosa
(C) mucosa → submucosa → circular muscles → longitudinal muscles
(D) submucosa → longitudinal muscles → circular muscles → mucosa.

Q.67 Out of four layers of alimentary canal, which one forms villi, (finger-like projection)?
(A) Serosa (B) Mucosa
(C) Submucosa (D) Muscularis

Q.68 Teeth adapted for crushing and grinding are –
(A) premolars & molars (B) incisors
(C) incisors and premolars (D) canines

Q.69 Small projections found on the upper surface of tongue are called –
(A) frenulus (B) taste buds
(C) sulcus terminals (D) papillae

Q.70 Which one of the following sequence is in correct order?
(A) Descending portal colon → Rectum → Anus
(B) Colon → Anus → Rectum
(C) Stomach → Jejunum → Duodenum
(D) Ileum → Colon → Caecum

Q.71 Which of the following statements is incorrect?
(A) Brunner's glands are submucosal
(B) Irregular folds of gastric mucosa are rugae
(C) Glisson's capsule is the connective tissue sheath of hepatic lobule
(D) Mesothelium or serosa lies in close proximity to the circular layer of muscularis

Q.72 Opening of oesophagus into J-shaped, bag-like structure is regulated by
(A) pyloric sphincter
(B) sphincter of oddi
(C) ileocaceal sphincter
(D) gastro oesophageal sphincter

Q.73 The layer of tissue that lines the lumen of the digestive tract is the
(A) muscle layer (B) visceral peritoneum
(C) parietal peritoneum (D) mucosa

Q.74 Which of the following are accessory digestive glands?
(A) salivary glands (B) pancreas
(C) liver (D) all of these

Q.75 Which of the following is the correct sequence?
(A) pharynx → stomach → esophagus
(B) stomach → large intestine → small intestine
(C) esophagus → pharynx → stomach
(D) pharynx → esophagus → stomach

PART - 2 : DIGESTION OF FOOD

Q.76 What is the major site for the conversion of proteins into free amino acids?
(A) Spleen (B) Liver
(C) Intestine (D) Kidney

Q.77 Choose the correct statement
(A) The gastro-oesophageal sphincter controls the passage of food into the stomach.
(B) HCl provides the acidic pH optimal for pepsins.
(C) Pancreatic juice and bile are released through the hepato-pancreatic duct.
(D) All of these

Q.78 In which of the following order, the process of digestion proceeds?
(1) Digestion → Ingestion → Absorption → Accumulation → Egestion
(2) Digestion → Ingestion → Accumulation → Absorption → Egestion
(3) Ingestion → Digestion → Assimilation → Absorption → Egestion
(4) Ingestion → Digestion → Absorption → Assimilation → Egestion

Q.79 Name the process by which swallowed food is conveyed to pharynx and oesophagus respectively.
(A) Deglutition (B) Peristalsis
(C) Ingestion (D) Succus entricus

Q.80 Digestion is accomplished by
(A) mechanical and chemical processes
(B) chemical processes only
(C) mechanical processes only
(D) None of the above

Q.81 What is the composition of bile?
(A) Bile pigments and bile salts.
(B) Bile pigments and cholesterol.
(C) Cholesterol and phospholipids.
(D) All of the above

Q.82 Enzyme enterokinase helps in the conversion of
(A) caesinogen into caesin
(B) trypsinogen into trypsin
(C) pepsinogen into pepsin
(D) proteins into polypeptides

Q.83 For how much duration, food is stored in the stomach?
(A) 3-4 hours (B) 2-4 hours
(C) 4-5 hours (D) 5-6 hours

Q.84 Which category of compound is most concentrated energy source?
(A) Lipids (B) Carbohydrates
(C) Proteins (D) Vitamins

Q.85 Hydrolysis of milk sugar gives rise to
(A) two molecules of lactose.
(B) two molecules of glucose.
(C) one molecule of glucose and one molecule of fructose.
(D) one molecule of glucose and one molecule of galactose.

Q.86 Which is the inactive form of enzyme, pepsin?
(A) Pepsinogen (B) Protease
(C) Trypsin (D) Peptones

Q.87 Select the incorrect statement.
(A) Lipases and nucleases are not present in pancreatic juice.
(B) Goblet cells secrete mucus.
(C) Brunner's glands are sub-mucosal glands.
(D) Carboxypeptidase catalyses conversion of proteins, peptones & proteoses to dipeptides.

Q.88 Which of the following secretions gets mixed with the food (hydrolysed) in the small instestine?
(A) Bile, pancreatic juices and intestinal juices.
(B) Pancreatic juices, intestinal juices and gastric juices.
(C) Gastric juices, intestinal juices and biles.
(D) Bile, gastric juices and salivary juices.

Q.89 A bolus is –
(A) a mass of crushed food moistened with saliva.
(B) the semisolid material resulting from partial digestion in the stomach.
(C) the milky emulsified fat absorbed from small intestine.
(D) indigestible materials that help in movement and absorption.

Q.90 Which of the following molecule can be digested by pancreatic juices?
(A) fat, protein and nucleic acids.
(B) carbohydrates and proteins.
(C) carbohydrates and fats.
(D) All of the above.

Q.91 Which part of the mammalian alimentary canal does not secrete any enzyme?
(A) Mouth (B) Oesophagus
(C) Stomach (D) Duodenum

Q.92 What is the medium of human saliva?
(A) Acidic (B) Basic
(C) Neutral (D) Highly acidic

Q.93 Digestion of proteins begins in the __(i)__ and digestion of polysaccharides begins in the __(ii)__
(A) (i)-mouth, (ii)-stomach
(B) (i)-stomach, (ii)-small intestine
(C) (i)-stomach, (ii)-mouth
(D) (i)-stomach, (ii)-stomach

Q.94 The gastric juices contain
(A) trypsin, rennin, pepsin
(B) pepsin, trypsin, amylase
(C) pepsin, rennin, carbohydrates
(D) pepsin, lipase, rennin

Q.95 What name would you suggest for a thoroughly mixed food with gastric juices by the churning movements of muscular stomach wall?
(A) Bolus (B) Chyme
(C) Either bolus or chyme (D) None of these

Q.96 Select what is not true of intestinal villi among followings
(A) They possess microvilli.
(B) They increase the surface area.
(C) They are supplied with capillaries and the lacteal vessels.
(D) They only participate in digestion of fats.

Q.97 Enzyme sucrase hydrolyses sucrose into
(A) glucose and galactose
(B) glucose and fructose
(C) two molecule of glucose
(D) two molecule of fructose

PART - 3 : ABSORPTION OF DIGESTED PRODUCTS

Q.98 The process by which absorbed food are utilised by the tissues in the living being for energy, growth and maintenance is termed as –
(A) absorption (B) assimilation
(C) catabolism (D) digestion & absorption

Q.99 What do you mean by the absorption of food?
(A) It is a process by which the end products of the digestion passes through the intestinal mucosa into blood or lymph.
(B) It is a process of transportation of digestive food from the human alimentary canal to blood and lymph.
(C) It is a process to utilise the absorbed food substances.
(D) Absorption is a process by which nutrients are absorbed from the large intestine into the blood and lymph through its mucous membrane.

Q.100 Process of absorption of nutrients is carried by
(A) passive transport (B) facilitated transport
(C) active transport (D) All of the above

Q.101 By which process, absorption of galactose, electrolytes, like Na^+ and K^+ and some amine acids takes place?
(A) Active process (B) Passive process
(C) Simple diffusions (D) Osmosis

Q.102 Major site of absorption of nutrients in human beings is
(A) stomach (B) small intestine
(C) large intestine (D) Both (A) and (B)

Q.103 Which of the following statements is false?
(A) The breakdown of most of biomacromolecules occurs in duodenum.
(B) Simple substances (digested foods) are absorbed in the jejunum and ileum.
(C) Significant digestive activity occurs in large intestine
(D) Undigested and unabsorbed substances are passed on to the large intestine.

Q.104 What is the main site of amino acids absorption in human's small intestine?
(A) Duodenum (B) Jejunum
(C) Ileum (D) Both (A) and (B)

Q.105 Which of the following is absorbed from undigested food in the large intestine?
(A) Water and vitamins
(B) Water and product of bacterial digestion
(C) Water and salt
(D) Water and alcohols

PART - 4 : DISORDERS OF DIGESTIVE SYSTEM

Q.106 The abnormal frequent movement of the bowl and increased liquidity of the faeces is called
(A) vomiting (B) indigestion
(C) constipation (D) diarrhoea

Q.107 Anxiety and eating spicy food together in an otherwise normal human, may lead to –
(A) indigestion (B) jaundice
(C) diarrhoea (D) vomiting

Q.108 Why the eyes of the patients turns yellow during jaundice?
(A) Due to the deposition of bile pigments.
(B) Due to the ejection of stomach content through mouth.
(C) Due to the stomach malfunctioning.
(D) Due to the excessive vomiting.

Q.109 What is gastroporesis?
(A) Inflammation of the lining of the stomach
(B) Stomach content flows back up into the oesophagus.
(C) Delayed movement of food from the stomach to the small intestine.
(D) Bleeding in the digestive tract.

EXERCISE - 2 (LEVEL-2)

Choose one correct response for each question.

Q.1 Digestion is the utilization of organic molecules for which fundamental processes associated life?
(A) ATP production
(B) synthesis of biological molecules
(C) reproduction
(D) Both A and B

Q.2 Which of the following biological molecules has the most potential kcal per gram?
(A) fats (B) proteins
(C) carbohydrates (D) nucleic acids

Q.3 Essential amino acids and vitamins must be –
(A) synthesized before any of the others.
(B) obtained in the diet.
(C) metabolized before others can be synthesized.
(D) obtained from symbiotic relationship.

Q.4 An animal with teeth and claws would most likely be a __ feeder.
(A) fluid (B) suspension
(C) deposit (D) bulk

Q.5 Animals that intake food and remove wastes through the same opening have a –
(A) saclike digestive system
(B) tubelike digestive system
(C) filtering digestive system
(D) gizzard

Q.6 Which of the following structures are not typically involved with mechanical processing?
(A) gizzard (B) stomach
(C) pancreas (D) crop

Q.7 Bile is principally involved in the digestion of –
(A) carbohydrates (B) lipids
(C) starch (D) nucleic acids

Q.8 Excess carbohydrates and proteins are stored in the body as –
(A) amino acids (B) fats
(C) starch (D) monosaccharide

Q.9 Which of the following kills bacteria in the human alimentary canal?
(A) Gastric juice (B) Mucus
(C) Pancreatic juice (D) Saliva

Q.10 Which of the following does NOT occur in the liver?
(A) Sugars are converted to glycogen & stored
(B) Production of insulin
(C) Production of enzymes
(D) Fat oxidization

Q.11 The process of digestion starts from
(A) stomach (B) oesophagus
(C) mouth (D) intestine

Q.12 The epithelial cells lining the stomach of vertebrates are protected from damage by HCl because
(A) HCl is too dilute.
(B) the epithelial cells are resistant to the action of HCl.
(C) HCl is neutralized in the stomach.
(D) the epithelial cells are covered by a mucus secretion.

Q.13 These absorption of water, alcohol and monosaccharides occur in
(A) gastric mucosa
(B) mucosa of ileum
(C) intestinal mucosa
(D) through out epithelium of stomach

Q.14 Small finger-like projection, which produce numerous microscopic projections are supplied with a network of
(A) blood capillaries and lacteal.
(B) blood capillaries only.
(C) lacteal only.
(D) a large lymphoid vessel and valves.

Q.15 Which of the following statements is incorrect?
(A) Mucosal epithelium has goblet cells which secrete mucus for lubrication.
(B) Mucosa forms gastric glands in the stomach and crypts in between the bases of villi in intestine.

(C) Cells lining the villi has brush border or microvilli.
(D) All the four basic layers in the wall of gut never show modifications in different parts of the alimentary canal.

Q.16 Digestion of starch starts from the mouth, whereas __ is the site of digestion mainly for ___.
(A) stomach; protein
(B) stomach; starch
(C) small intestine; protein
(D) small intestine; starch

Q.17 Which of the following statements is incorrect?
(A) Faecal accumulation in the rectum initiates a neural reflex causing an urge for its removal.
(B) Irregular bowel movements cause constipation.
(C) In diarrhoea absorption of food is increased.
(D) All of these.

Q.18 Taste buds are present on
(A) small projection found on the upper surface of tongue.
(B) small projection found on the lower surface of tongue.
(C) on both the surface of tongue.
(D) behind the tongue.

Q.19 The contraction of gall bladder is due to
(A) cholecystokinin (B) enterogastrone
(C) gastrin (D) secretin.

Q.20 I. Caecum, the ___ part of large intestine which host symbiotic microorganisms.
II. A finger like tubular projection, ____ arises from the caecum.
(A) first, colon
(B) second, rectum
(C) first, vermiform appendix
(D) second, vermiform appendix

Q.21 Which of the following statements is incorrect about pancreas?
(A) It is compound gland as it has both exocrine and endocrine part.
(B) Exocrine part secretes alkaline pancreatic juice having enzymes.
(C) Endocrine part secretes hormones like insulin and glucagon.
(D) It is surrounded by Glisson's capsule.

Q.22 Absorption of fat occurs through the process of
(A) active transport (B) passive transport
(C) osmosis (D) simple diffusion

Q.23 Which of the following is the function of enterogastrone?
(A) It inhibits the secretion of gastric juice.
(B) It stimulates the secretion of digestive juices in the stomach.
(C) It stimulates the flow of pancreatic juice.
(D) It regulates the flow of bile.

Q.24 Which is the hardest material of the human body?
(A) Dentine (B) Enamel
(C) Teeth (D) Bone

Q.25 Which one is not a part of large intestine?
(A) Rectum (B) Caecum
(C) Ileum (D) Colon

Q.26 Crypts of Lieberkuhn are present in –
(A) pancreas and secrete pancreatic juice
(B) small intestine and secrete digestive enzymes
(C) stomach and secrete dilute HCl
(D) stomach and secrete trypsin.

Q.27 Choose the most appropiate option to describe the composition of human saliva.
(A) amylase, hydrolase
(B) electrolytes amylase/ptylin, lysozymes and mucous
(C) amylase/ptylin, mucous
(D) ptylin only

Q.28 The inflammation of intestinal tract is due to the infection of which rnicrorganism?
(A) bacteria (B) virus
(C) fungus (D) Both (A) and (B)

Q.29 Which of the following is not a salivary gland?
(A) Sublingual (B) Submaxillary
(C) Lacrimal (D) Parotid

Q.30 Which of the following fatty acids is not synthesised in the human body?
(A) Glycerol (B) Cholesterol
(C) Linoleic acid (D) None of these

Q.31 In which of the following secretions, the enzymes, like maltase, isomaltase, sucrase, lactase, enterokinase, aminopeptidase, dipeptidase, nucleosidases, nucleotidases and α-dextrinase are present?
(A) pancreatic juices (B) intestinal juices
(C) gastric juices (D) Both (A) and (B)

Q.32 Which part of the small intestine absorb iron, calcium and amino acids?
(A) Duodenum (B) Jejunum
(C) Ileum (D) Both (A) and (B)

Q.33 The site of action and substrate of rennin are respectively
(A) mouth and starch
(B) small intestine and protein
(C) stomach and casein
(D) stomach and fat.

Q.34 What do you mean by dental formula?
(A) An arrangement of teeth in mouth in the order of I, C, PM, M.
(B) An arrangement of teeth in each half of the upper and lower jaw in the order of I, C, PM, M.
(C) An arrangement of teeth in upper jaw in the order to I, C, PM, M.
(D) An arrangement of teeth in the lower jaw in the order to I,C, PM, M.

Q.35 If you chew on a piece of bread long enough, it will begin to taste sweet because
(A) maltase is breaking down maltose
(B) lipases are forming fatty acids
(C) amylase is breaking down starches to disaccharides
(D) disaccharides are forming glucose.

Q.36 Seggregate the following statements into true and false category.
I. Mucosal epithelium has goblet cells which secrete mucous and helps in lubrication.
II. Mucosa forms gastric glands in the stomach and crypts in between the bases of villi in intestine.
III. Cells lining the villi has brush border or microvilli.
IV. All the four basic layers in the wall of gut never shows modification in different parts of the alimentary canal.
(A) All the statements are correct.
(B) I, II and III are true while IV is false.
(C) I, II and III are false while IV is true.
(D) I, IV are false, while II and III are true.

Q.37 If pH of stomach is 1.6, then which enzyme will digest protein?
(A) Amylase (B) Trypsin
(C) Erypsin (D) Pepsin

Q.38 What are the various type of secretions that are mixed with the food to-facilitate the digestion of food in the intestine?
(A) Bile salts, bile pigment and gastric juices.
(B) Bile, pancreatic juices and intestinal juices.
(C) Bile, chymotrypsinogen and trypsinogen.
(D) Bile salts, bile pigments and succus enterics.

Q.39 Which of the following statements is false?
(A) Intrinsic factor is essential for absorption of Vitamin B_{12}.
(B) Gastric gland never secretes even a small amount of lipase.
(C) Rennin, a proteolytic enzyme is found in gastric juice of infants.
(D) All of these

Q.40 Which one statement is incorrect regarding the process of digestion and absorption in humans?
(A) Small intestine is the major site for the absorption of all nutrients.
(B) Around 40% of the total absorption of nutrients takes place in the proximal part of the small intestine.
(C) Drugs, alcohols, little water and salt are absorbed in the stomach through the mucous membrane.
(D) Large intestine is the site of absorption for water and products of bacterial digestion.

Q.41 Dental formula in human beings is

(A) $\frac{3223}{3223}$ (B) $\frac{2123}{2123}$

(C) $\frac{1232}{1232}$ (D) $\frac{2233}{2233}$

Q.42 Liver is the largest gland and is associated with various functions, choose one which is not correct
(A) Metabolism of carbohydrate
(B) Digestion of fat
(C) Formation of bile
(D) Secretion of hormone called gastric

Q.43 Which of the following animal exhibits diphyodont dentition?
(A) Snakes (B) Crocodiles
(C) Horse (D) Elephant

Q.44 The back flow of faecal matter from the large intestine into the small intestine is prevented by the presence of –
(A) epiglottis
(B) sphincter of Oddi
(C) ileo-caecal valve
(D) gastro-oesophageal sphincter.

Q.45 Bile juice is stored in which organ –
(A) Gall bladder (B) Liver
(C) Kidney (D) Pancreas

Q.46 Secretin –
(A) stimulates enzyme secretion by pancreas, inhibits acid secretion in stomach, stimulates gall bladder.
(B) stimulates bicarbonate secretion by pancreas, inhibits acid secretion in stomach, stimulates bicarbonate secretion by liver
(C) stimulates acid secretion in stomach, potentiates action of CCK, inhibits intestinal movement.
(D) stimulates gall bladder, inhibits acid secretion in stomach, stimulates bicarbonate secretion by pancreas.

Q.47 In human beings, digestion of carbohydrates starts from the mouth. How much percentage of it is digested in the mouth?
(A) 10-20% (B) 25-30%
(C) 60%-75% (D) About 85%

Q.48 Which of the following components of food will be affected if the pH of stomach is made 7?
(A) Fat (B) Protein
(C) Sucrose (D) Vitamins

Q.49 Which part of digestive system is affected in celiac disease?
(A) Large intestine (B) small intestine
(C) Stomach (D) Duodenum

Q.50 Point out the wrong enzymatic reaction.
(A) Sucrose $\xrightarrow{\text{Invertase}}$ Glucose + Fructose
(B) Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Fructose
(C) Pepsinogen $\xrightarrow{\text{HCl}}$ Pepsin
(D) Maltose $\xrightarrow{\text{Maltase}}$ Glucose + Glucose

Q.51 Which part of small intestine opens into large intestine?
(A) Colon (B) Jejunum
(C) Ileum (D) Duodenum

Q.52 Succus entericus is secreted by
(A) Goblets cells
(B) Crypt of Lieberkuhn
(C) Islets of lengerhans
(D) Paneth cells

Q.53 Facilated transport, facilitates the absorption of
(A) fructose (B) amino acid
(C) glucose (D) Both (A) and (B)

Q.54 Choose the correct order of true (T) and false(F) for following statements –
(i) The stomach has the lowest pH.
(ii) The liver contains lipid emulsifier.
(iii) Large intestine secretes many enzymes.
(iv) All proteases function in the lumen of small intestine.
(A) (i) - T, (ii) - F, (iii) - T, (iv) - F
(B) (i) - F, (ii) - T, (iii) - F, (iv) - T
(C) (i) - F, (ii) - F, (iii) - T, (iv) - T
(D) (i) - T, (ii) - T, (iii) - F, (iv) - F

EXERCISE - 3 (LEVEL-3)

Choose one correct response for each question.

Q.1 Which of the following is incorrectly matched?
(A) Giraffes-long intestinal tract
(B) Tigers-short intestinal tract
(C) Horse-long intestinal tract
(D) Kangaroo-short intestinal tract

Q.2 Joe has bleeding problems; he had been on antibiotics for 6 weeks. You know what is wrong. The long-term antibiotics
(A) decreased the bacteria which produce vitamin D.
(B) decreased the bacteria which produce vitamin K.
(C) increased the level of water-soluble vitamins.
(D) have nothing to do with the bleeding problems.

Q.3 The table below represents the composition of three foods, X, Y and Z.

Nutrient	Content (g/100 g)		
	X	Y	Z
Fat	3.8	1.8	82.5
Protein	3.3	9.2	0.5
Carbohydrate	4.8	49.0	0.0
Calcium	120.0	92.0	15.0
Iron	0.1	1.8	0.2

Which of the following correctly identifies X, Y and Z respectively?
(A) Bread, butter, milk (B) Butter, bread, milk
(C) Milk, bread, butter (D) Milk, butter, bread

Q.4 The table below shows the composition of a can of baked beans.

Substance	Content (g/100 g)
Protein	5.2
Carbohydrate	9.0
Fat	0.4
Dietary fibre	7.3
Added sugar	2.0
Added salt	0.8

Which substance in the can of baked beans helps food pass quickly through the alimentary canal?
(A) Added sugar (B) Dietary fibre
(C) Carbohydrate (D) Protein

Q.5 An enzyme X digests protein in the stomach. Four test tubes, containing the same amounts of protein and enzyme X, are kept at different levels of pH and temperature as shown in the table. In which tube will protein digestion be quickest?

	Test tube	pH	Temperature
(A)	1	2	20°C
(B)	2	7	35°C
(C)	3	2	35°C
(D)	4	7	20°C

Q.6 Read the following statements regarding the digestive system and select the correct statement.
(A) Oesophagus passes through neck, thorax and diaphragm and open into stomach.
(B) Stomach is located in the upper right portion of the abdominal cavity.
(C) Stomach, a J-shaped organ is the longest organ of alimentary canal.
(D) Caecum, a small blind sac is a part of small intestine and host symbiotic bacteria.

Q.7 Hydrolysis of maltose gives rise to –
(A) two molecules of glucose.
(B) two molecules of galactose.
(C) one molecule of glucose and one molecule of galactose.
(D) one molecule of glucose and one molecule of fructose.

Q.8 What is the correct dental formula of rat?

(A) $I\frac{2}{2}C\frac{1}{1}PM\frac{2}{2}M\frac{3}{3}$ (B) $I\frac{2}{1}C\frac{1}{1}PM\frac{2}{2}M\frac{3}{3}$

(C) $I\frac{1}{2}C\frac{2}{1}PM\frac{2}{2}M\frac{3}{3}$ (D) $I\frac{1}{1}C\frac{0}{0}PM\frac{0}{0}M\frac{3}{3}$

Q.9 Intestinal lymphangiectasia is characterised by
(A) dilated intestinal lacteals
(B) contracted intestinal lacteals
(C) descreased number of peneth cells
(D) increased number of paneth cells

Q.10 Which enzymes are responsible to convert the end product of partially hydrolysed food into simple absorbable forms?
(A) Enzymes of succus entericus
(B) Proteolytic enzyme of pancreatic juice
(C) Enzyme of gastric juice
(D) All of the above

Q.11 Which one of the following statements is/are correct?
I. Frenulum is the fold by which tongue is attached to the floor of mouth or oral cavity.
II. Lower surface of the tongue has little projection which bears taste buds.
III. Pharynx is the common passage for food and air.
IV. Sphincter of oddi guards and regulates the opening of stomach into duodenum .
V. Colon has 3 parts an ascending, a transverse and descending part and the later opens into the rectum.
(A) I, II and III are correct
(B) IV and V are correct
(C) I, II, III, IV and V
(D) I, III and V are correct

Q.12 The reflex action during vomiting is controlled by vomit centre in ____. The feeling of ____ precedes vomiting.
(A) medulla; nausea (B) cortex; anxiey
(C) medulla; skin irritation (D) pons; nausea

Q.13 Read the following four statements (i) - (iv) with certain mistakes in two of them.
(i) Fructose is generally absorbed by simple diffusion.
(ii) The digestive wastes, solidified into coherent faeces in the rectum initiate an endocrinal action causing an urge or desire for its removal.
(iii) 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.
(iv) The secretions of the brush border cells of the mucosa alongwith the secretions of the goblet cells constitute the succus entericus.
Which of the above two statements have mistakes?
(A) (i) and (ii) (B) (ii) and (iii)
(C) (iii) and (iv) (D) (i) and (iii)

Q.14 The form, in which the synthesised fats liberated from the intestinal wall into the lymph present in the lymphatic capillaries is –
(A) micelles (B) chylomicrons
(C) fatty acids (D) Both (A) and (B)

Q.15 Match the columns –

	Column I	**Column II**
a.	Duodenum	i. A cartilaginous flap
b.	Epiglottis	ii. Small blind sac
c.	Glottis	iii. 'U' shaped structure emerging from the stomach
d.	Caecum	iv. Opening of wind pipe

(A) a-i, b-ii, c-iii, d-iv (B) a-iv, b-iii, c-ii, d-i
(C) a-iii, b-i, c-iv, d-ii (D) a-ii, b-iv, c-i, d-iii

Q.16 Choose true and false statements.
I. Digestion of starch starts from the mouth.
II. Around 30% of the starch is digested in the stomach.
III. Digestion of food requires the action of pancreatic juices.
IV. Digestion of food is completed in the longest part of the alimentary canal.
(A) All are true
(B) I, III and IV are true while II is false
(C) II and III are false while III and I are true
(D) II and IV are false while III and I are true.

Q.17 Which one of the following pairs of the kind of cells and their secretion is correctly matched ?
(A) Oxyntic cells - a secretion with pH between 2.0 and 3.0.
(B) Alpha cells of islets of Langerhans - secretion that decreases blood sugar level
(C) Kupffer cells - a digestive enzyme that hydrolyses nucleic acids.
(D) Sebaceous glands - a secretion that evaporates for cooling.

Q.18 Which one is not associated with the secretion of saliva in human being?

(A) Paratoids glands (B)Sublinguals glands
(C) Zymogenic cells (D) Sub-maxillary glands

Q.19 Choose true (T) and false (F) statements.

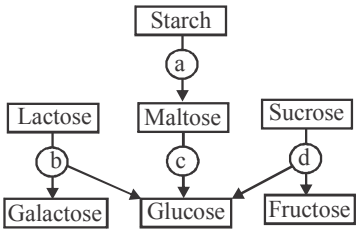
(i) Amylase hydrolyzes proteins to amino acids.
(ii) Pancreatic amylase hydrolyses polysaccharides to disaccharides.
(iii) Enteropeptidase activates pepsinogen to pepsin.
(iv) Trypsin coagulates the milk protein casein.

(A) (i) - T, (ii) - T, (iii) - F, (iv) - F
(B) (i) - F, (ii) - T, (iii) - F, (iv) - T
(C) (i) - F, (ii) - T, (iii) - F, (iv) - F
(D) (i) - F, (ii) - T, (iii) - T, (iv) - F

Q.20 Which of the following is the constituent of pancreatic juices?

(A) Sodium bicarbonate and three proenzymes.
(B) Potassium bicarbonate & three proenzymes.
(C) Sodium bicarbonate and five proenzymes.
(D) Potassium bicarbonate and five proenzymes.

Q.21 The given flowchart shows the fate of carbohydrates during digestion in the human alimentary canal. Identify the enzymes acting at stages indicated as a, b, c and d and select the correct option.

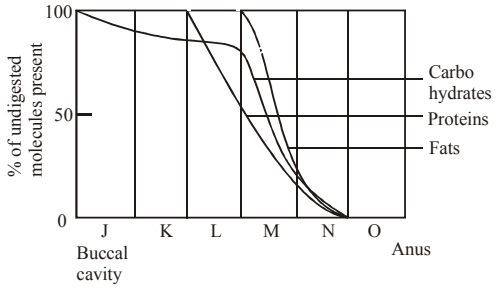


(A) a - amylase, b - maltase, c - lactase, d - invertase
(B) a - amylase, b - maltase, c - invertase, d - lactase
(C) a - amylase, b - invertase, c - maltase, d - lactase
(D) a - amylase, b - lactase, c - maltase, d - invertase

Q.22 Which one of the following equation match correctly with the action of enzymes –

(A) Stomach → Fats $\xrightarrow{\text{Lipase}}$ Micelles
(B) Small intestine → Proteins $\xrightarrow{\text{Pepsin}}$ Amino acids
(C) Small intestine → Starch $\xrightarrow{\text{amylase}}$ Disaccharides
(D) Duodenum → Triglycerides $\xrightarrow{\text{Trypsin}}$ Monoglycerides

Q.23 The figure below shows where carbohydrates, proteins and fats are digested as food moves along the parts of the alimentary canal J to O.



Which of the following correctly identifies K, L, M and N?

(A) K-Large intestine, L-Small intestine, M-Stomach, N-Oesophagus
(B) K-Oesophagus, L-Small intestine, M-Large intestine, N-Rectum
(C) K-Oesophagus, L-Stomach, M-Small intestine, N-Large intestine
(D) K-Stomach, L-Oesophagus, M-Small intestine, N-Large intestine

Q.24 Which of the following adaptations about the intestinal villi is not true?

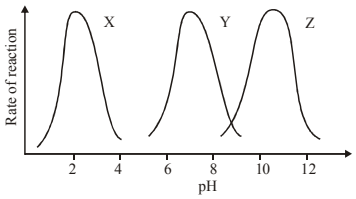
	Feature	Adaptation
(A)	Rich in blood vessels	Absorbs amino acids
(B)	Rich in blood vessels	Absorbs glucose
(C)	Surface folded	Increases the surface area of absorption
(D)	Thin-walled	Allows proteins to pass into the blood

Q.25 A child took sugarcane and sucked its juice, Which of the following match is correct regarding this?

Substrate	Enzyme	Site of secretion of enzyme	Products formed
(A) Proteins	Pepsin	Duodenum	Polypeptides
(B) Starch	Amylase	Salivary glands	Glucose
(C) Lipids	Lipase	Pancreas	Fat globules
(D) Sucrose	Invertase	Duodenum	Glucose + Fructose

For questions 26 and 27

Refer to the diagram below which shows the effect of pH on the activities of three enzymes, X, Y and Z.



Q.26 Which of the following statements is the best conclusion from the graph?

(A) Enzymes are biological catalysts.
(B) Enzymes are easily denatured.
(C) Enzymes can work best at their narrow range of pH.
(D) Enzymes cannot work at pH 5.

Q.27 Which of the following are the possible locations in man where the three enzymes can be found?

	X	Y	Z
(A)	Duodenum	Mouth	Stomach
(B)	Mouth	Stomach	Duodenum
(C)	Stomach	Duodenum	Mouth
(D)	Stomach	Mouth	Duodenum

Q.28 Match Column-I with Column-II

Column-I (Types of cell)	**Column-II (Secretions)**
a. Peptic cells	(i) Mucus
b. Oxyntic cells	(ii) Alkaline fluid
c. Goblet cells	(iii) Pro-enzymes
	(iv) HCl

(A) a-(ii), b-(i), c-(iv) (B) a-(iv), b-(iii), c-(ii)
(C) a-(iv), b-(i), c-(ii) (D) a-(iii), b-(iv), c-(i)

Note (Q.29-Q.36) :

(A) S-1 is True, S-2 is True, S-2 is a correct explanation for S-1
(B) S-1 is True, S-2 is True; S-2 is NOT a correct explanation for S-1
(C) S-1 is True, S-2 is False
(D) S-1 is False, S-2 is False

Q.29 **Statement 1 :** Rumen of alimentary canal of ruminant animals harbour numerous bacteria and protozoa.
Statement 2 : Bacteria and protozoa help in the secretion of gastric juice in the rumen.

Q.30 **Statement 1 :** Presence of HCl in stomach is necessary for the process of digestion.
Statement 2 : HCl kills and inhibits the growth of bacteria in the stomach.

Q.31 **Statement 1 :** Chewing is one of the important process of digestion in animals.
Statement 2 : It helps in enzyme action.

Q.32 **Statement 1 :** The second largest digestive gland in our body is pancreas.
Statement 2 : Pancreas functions both as an exocrine and endocrine gland.

Q.33 **Statement 1 :** The worm-like structure attached to the caecum at the beginning of the large intestine is known as the vermiform appendix.
Statement 2 : Vermiform appendix has no apparent digestive function.

Q.34 **Statement 1 :** Deglutition starts as a reflex and then continues by voluntary action.
Statement 2 : Oesophagus has smooth muscles in the beginning and striated muscles in the rest of its wall.

Q.35 **Statement 1 :** The human small intestine is the longest portion in the alimentary canal.
Statement 2 : Absorption of digested food requires a very large surface area.

Q.36 **Statement 1 :** Dental formula gives the number of teeth in the half of each jaw.
Statement 2 : Dental formula can be expressed for insectivorous mammals as well as for the non-mammalian vertebrates.

EXERCISE - 4 (PREVIOUS YEARS AIPMT/NEET EXAM QUESTIONS)

Choose one correct response for each question.

Q.1 Select the correct match of the digested products in humans given in column I with their absorption site and mechanism in column II. **[NEET 2013]**

	Column I	Column II
(A)	Cholesterol, maltose	Large intestine, active absorption
(B)	Glycine, glucose	small intestine, active absorption
(C)	Fructose, Na+	small intestine, passive absorption
(D)	Glycerol, fatty acids	duodenum, move as chilomicrons

Q.2 The initial step in the digestion of milk in humans is carried out by? **[AIPMT 2014]**
(A) Lipase (B) Trypsin
(C) Rennin (D) Pepsin

Q.3 Fructose is absorbed into the blood through mucosa cells of intestine by the process called –
(A) Active transport **[AIPMT 2014]**
(B) Facilitated transport
(C) Simple diffusion
(D) Co-transport mechanism

Q.4 Which one of the following statement is true regarding digestion and absorption of food in humans? **[AIPMT 2015]**
(A) Oxyntic cells in our stomach secrete the proenzyme pepsinogen.
(B) Fructose and amino acids are absorbed through intestinal mucosa with the help of carrier ions like Na^+.
(C) Chylomicrons are small lipoprotein particles that are transported from intestine into blood capillaries.
(D) About 60% of starch is hydrolysed by salivary amylase in our mouth.

Q.5 The primary dentition in human differs from permanent dentition in not having one of the following type of teeth– **[RE-AIPMT 2015]**
(A) Premolars (B) Molars
(C) Incisors (D) Canine

Q.6 The enzyme that is not present in succus Entericus is : **[RE-AIPMT 2015]**
(A) nucleases (B) nucleosidase
(C) lipase (D) maltase

Q.7 In the stomach, gastric acid is secreted by the **[NEET 2016 PHASE 1]**
(A) Gastrin secreting cells (B) Parietal cells
(C) Peptic cells (D) Acidic cells

Q.8 Which of the following guards the opening of hepatopancreatic duct into the duodenum? **[NEET 2016 PHASE 1]**
(A) Semilunar valve (B) Ileocaecal valve
(C) Pyloric sphincter (D) Sphincter of Oddi

Q.9 Which cells of 'Crypts of Lieberkuhn' secrete antibacterial lysozyme? **[NEET 2017]**
(A) Argentaffin cells (B) Paneth cells
(C) Zymogen cells (D) Kupffer cells

Q.10 A baby boy aged two years is admitted to play school and passes through a dental check-up. The dentist observed that the boy had twenty teeth. Which teeth were absent? **[NEET 2017]**
(A) Incisors (B) Canines
(C) Pre-molars (D) Molars

Q.11 Which of the following options best represents the enzyme composition of pancreatic juice? **[NEET 2017]**
(A) Amylase, peptidase, trypsinogen, rennin.
(B) Amylase, pepsin, trypsinogen, maltase.
(C) Peptidase, amylase, pepsin, rennin.
(D) Lipase, amylase, trypsinogen, procarboxypeptidase

Q.12 Which of the following gastric cells indirectly help in erythropoiesis? **[NEET 2018]**
(A) Goblet cells (B) Mucous cells
(C) Chief cells (D) Parietal cells

Q.13 Which of the following terms describe human dentition? **[NEET 2018]**
(A) Pleurodont, Monophyodont, Homodont
(B) Thecodont, Diphyodont, Heterodont
(C) Thecodont, Diphyodont, Homodont
(D) Pleurodont, Diphyodont, Heterodont

Q.14 Match the following structures with their respective location in organs **[NEET 2019]**

(a) Crypts of Lieberkuhn	(i) Pancreas
(b) Glisson's Capsule	(ii) Duodenum
(c) Islets of Langerhans	(iii) Small intestine
(d) Brunner's Glands	(iv) Liver

Select the correct option from the following

(A) a-(iii), b-(i), c-(ii), d-(iv)
(B) a-(ii), b- (iv), c-(i), d-(iii)
(C) a-(iii), b- (iv), c-(i), d-(ii)
(D) a-(iii), b-(ii), c-(i), d-(iv)

Q.15 Identify the cells whose secretion protects the lining of gastro-intestinal tract from various enzymes. **[NEET 2019]**

(A) Chief Cells (B) Goblet Cells
(C) Oxyntic Cells (D) Duodenal Cells

ANSWER KEY

EXERCISE-1 (SECTION-1&2)

(1) (A) **(2)** (B) **(3)** (A)
(4) (A) **(5)** (B) **(6)** (B)
(7) mouth **(8)** teeth
(9) salivary glands **(10)** esophagus
(11) gastroesophageal **(12)** stomach
(13) 3 **(14)** Gastric
(15) HCl **(16)** pepsinogen
(17) acidicity **(18)** mucus
(19) pyloric **(20)** small intestine
(21) pancreas **(22)** liver
(23) mucosa **(24)** digestion
(25) absorption **(26)** ileocecal
(27) colon or large intestine **(28)** water
(29) rectum **(30)** feces
(31) anus **(32)** breakdown
(33) smaller **(34)** absorbed
(35) enzymatic hydrolysis **(36)** specific
(37) bond **(38)** molecule
(39) intracellular **(40)** extracellular.

EXERCISE - 1 [SECTION-3 & 4]

Q	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
A	C	B	A	A	D	B	B	D	A	D	D	D	A	B	A	D	B	C	D	B	A	B	A	B	A
Q	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
A	B	B	A	D	A	D	D	D	D	D	C	D	D	A	A	D	B	C	A	D	A	A	A	A	D
Q	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109						
A	B	A	C	B	B	D	B	B	A	D	A	B	C	D	B	D	A	A	C						

EXERCISE - 2

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	D	A	B	D	A	C	B	B	A	B	C	D	A	A	D	A	C	A	A	C	D	D	A	B	C
Q	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
A	B	B	D	C	C	B	A	C	B	C	B	D	B	B	B	B	D	C	C	A	D	B	B	B	B
Q	51	52	53	54																					
A	C	B	D	D																					

EXERCISE - 3

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
A	D	B	C	B	C	A	A	D	A	A	D	A	A	B	C	B	A	C	C	A	D	C	C	D	D
Q	26	27	28	29	30	31	32	33	34	35	36														
A	C	D	D	C	B	A	B	B	D	B	C														

EXERCISE - 4

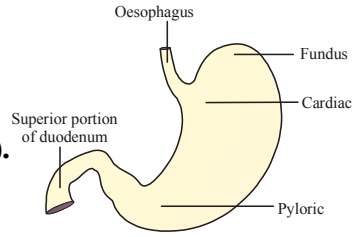
Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	C	B	B	A	A	B	D	B	C	D	D	B	C	B

SOLUTIONS

EXERCISE-1

(1) (A) **(2)** (B) **(3)** (A)
(4) (A) **(5)** (B) **(6)** (B)
(7) mouth **(8)** teeth
(9) salivary glands **(10)** esophagus
(11) gastroesophageal **(12)** stomach
(13) 3 **(14)** Gastric
(15) HCl **(16)** pepsinogen
(17) acidicity **(18)** mucus
(19) pyloric **(20)** small intestine
(21) pancreas **(22)** liver
(23) mucosa **(24)** digestion
(25) absorption **(26)** ileocecal
(27) colon or large intestine **(28)** water
(29) rectum **(30)** feces
(31) anus **(32)** breakdown
(33) smaller **(34)** absorbed
(35) enzymatic hydrolysis **(36)** specific
(37) bond **(38)** molecule
(39) intracellular **(40)** extracellular.

(41) **(C).**



(42) **(B).**

(43) **(A).** The villi (one is called a villus) are tiny, finger-shaped structures that increase the surface area. They have several important features:

- Wall just one cell thick - ensures that there is only a short distance for absorption to happen by diffusion and active transport.
- Network of blood capillaries - transports glucose and amino acids away from the small intestine in the blood.
- Internal structure called a lacteal - transports fatty acids and glycerol away from the small intestine in the lymph.

(44) **(A).**

(45) **(D).**

(46) **(B).** Different parts of the gut produce different enzymes.
Amylase: Salivary glands, pancreas, small intestine.
Protease : Stomach, pancreas, small intestine.
Lipase : Pancreas, small intestine.

(47) (B) **(48)** (D)

(49) **(A).** Proteases catalyse the breakdown of proteins into amino acids in the stomach and small intestine.

(50) **(D).** Most absorption occurs in small intestine.

(51) **(D).** Liver : Produces bile
Gall bladder : Stores bile before releasing it into the duodenum.

(52) **(D).** Normal digestion of dietary fat is accomplished by lipases with the assistance of bile, which is produced by the liver and normally supplied by way of the gallbladder.

(53) **(A).** **Villi** have thin cell walls to facilitate efficient absorption.

(54) **(B).** The lymphatic capillaries (lacteals) absorb lipids.

(55) **(A).** The duodenum precedes the jejunum and ileum and is the shortest part of the small intestine, where most chemical digestion takes place. In humans, the duodenum is a hollow jointed tube about 25–38 cm (10–15 inches) long connecting the stomach to the jejunum.

(56) **(D).** Food is one of the basic need of the living being that is taken to get necessary element, which in turn are helpful for growth and maintenance. Carbohydrates, proteins and fats constitutes the major components of food.

(57) **(B).** Gall bladder is a pear shaped sac-like structure attached to the posterior surface of the liver on the right side by connective tissue.

(58) **(C).** Liver is the largest gland of human body and in most of mammals body, second largest gland is pancreas. Liver is situated in the upper right side of abdominal cavity. It is a bilobed structure and is heavier in males than females.

(59) **(D).**

(60) **(B).** Throat (pharynx) can be divided into three parts, i.e., nasopharynx, oropharynx and laryngopharynx. The later part loads into the oesophagus behind and into the larynx (middle portion), which is a common passage for both food and air.

(61) **(A).** Stomach, it is a J-shaped structure of alimentary canal and consists of three parts, cardiac portion, fundic portion and pyloric portion. The last part, i.e., the pyloric portion opens into the proximal part of small intestine (duodenum).

(62) **(B).** The dental formula gives half of the total number of teeth. This is doubled to determine the full number. Children have milk teeth that include 8 incisors, 4 canines and 8 molars (premolars are absent). Therefore, dental formula of milk teeth is

$$\frac{2120}{2120} \times 2 = 20.$$

(63) **(A).** Oral cavity or buccal cavity consists of a number of teeth and a tongue. The later lies partially in pharynx. This muscular organ is attached to the floor of oral cavity by a median fold of mucous membrane called frenulum.

(64) **(B).** Gastric glands are located in the epithelial layer of the mucosa of stomach.

(65) **(A).** Digestion involves both mechanical and biochemical processing of food. Basically, it is the break down of complex organic substances of food like carbohydrates, proteins and fats(macronutrients) into simple, soluble inorganic substances. So, it can be defined as the conversion of insoluble polymer of food into their soluble monomers.

(66) **(B).** The lining of intestine from outside to inside is made up of outermost serosa, muscularis consisting of outer longitudinal and inner circular muscle fibres, submucosa and innermost mucosa.

(67) **(B).** The four basic layers of alimentary canal from the outer surface (or periphery) to inward towards the lumen are serosa → muscularis → submucosa → mucosa. The mucosa forms gastric glands in stomach and villi (small projection) in small intestine.

(68) **(A).** The Incisors are the teeth in the very front. They are the sharpest teeth, built to cut food and shaped to shovel the food inward.
The Canine teeth are in the corners of your mouth. Because they are meant for grasping and tearing food, they have very long roots.
Premolars are located just behind your Canine teeth. Premolars have a more flat chewing surface because they are meant for crushing food.
The Molars are the last teeth towards the back of your mouth. Molars are much bigger than the Premolars and have bigger, flatter chewing surfaces because their job is to chew and grind the food into smaller pieces.

(69) **(D).** Sulcus terminals (an inverted V shape furrow) divides the upper surface of furrow into buccal part and pharyngeal part. This upper surface of tongue has several small projections. These projection are termed as papillae.

(70) **(A).** Digestive system in mammals comprises an alimentary canal and concerned digestive glands. Human gut or alimentary canal consists of mouth → buccal cavity → pharynx → oesophagus (food pipes) → stomach → small intestine (duodenum → jejunum and → Ileum) → large intestine (caecum → colon → rectum). The large part of large intestine terminate into 2-3 cm long anal canal and its opening is called anus.
So, the correct chronological order is descending part of colon → rectum → anus.

(71) **(D).** Serosa is the outermost layer of alimentary canal and is made up of a thin mesothelium that lies in close proximity to the longitudinal layer of muscularis.

(72) **(D).** Oesophagus (food pipe), is a 25 cm long muscular tube, which transfers masticated food from pharynx to stomach. A sphincter lies at the opening between oesophagus and stomach.

This sphincter is called as gastro-oesophageal sphincter and the opening of oesophagus into stomach is regulated by this sphincter.

(73) **(D).** The wall of the digestive tract has four layers or tunics: Mucosa ; Submucosa ; Muscular layer ; Serous layer or serosa.
The mucosa, or mucous membrane layer, is the innermost tunic of the wall. It lines the lumen of the digestive tract. The mucosa consists of epithelium, an underlying loose connective tissue layer called lamina propria, and a thin layer of smooth muscle called the muscular is mucosa.

(74) **(D).** The salivary glands, liver, gallbladder, and pancreas are not part of the digestive tract, but they have a role in digestive activities and are considered accessory organs.

(75) **(D).**

(76) **(C).** The major site of protein break down into absorbable form, i.e., amino acids takes place in the small intestine. The process of conversion of the end products of food is carried out with the help of bile and intestinal juices.

(77) **(D).** The gastro-oesophageal sphincter controls the passage of food into the stomach.
HCl provides the acidic pH (pH 1.8) optimal for pepsins.
Pancreatic juice and bile are released through the hepato-pancreatic duct.

(78) **(D).**

(79) **(A).** The bolus is conveyed into the pharynx and then into the oesophagus by swallowing or deglutition. Succus entricus is the secretion of goblet cells, which is also known as intestinal juices. Bolus contain masticated food particles.

(80) **(A).**

(81) **(D).** Bile is secreted by liver and stored in gall bladder. Bile is a watery fluid, having bile salts, bile pigments and sodium bicarbonate, cholesterol, mucin, lecithin fats, etc. It is mixed with the food in intestine along with the pancreatic and intestinal juices.

(82) **(B).** Enterokinase is an enzyme present in intestinal juice. It helps in conversion of trypsinogen (inactive form of enzyme) into trypsin (active form of the enzyme) for protein digestion in the intestine.

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

$$\text{(inactive)} \xrightarrow{\text{acts on}} \text{proteins (active)}$$

(83) **(C).** The food is masticated by teeth and tongue in the buccal cavity with the help of saliva. Masticated food is swallowed with the help of buccal cavity. This masticated food (in the form of bolus) is pushed into pharynx and then into the food pipe. Food pipe transfers the food into cardiac part of stomach. In stomach food is stored for 4-5 hours. Some of the digestive proceses takes place in the stomach. Stomach is the main site of protein digestion.

(84) **(A).** Fats act as concentrated fuel. Their caloric value is 9.45 kcal/g and physiological fuel value is 9 kcal/g. They are more suitable as stored food.

(85) **(D).** Enzyme lactose hydrolyses milk sugar (lactose) into glucose and galactose.
Lactose $\rightarrow$ Glucose + Galactose

(86) **(A).** Pepsinogen is the inactive form of enzyme pepsin. Pepsinogen is secreted by peptic or chief cell of gastric gland and is activated by HCl acid - a secretion of parietal cells of gastric glands. Pepsinogen$\rightarrow$ Pepsin.

(87) **(A).** Pancreatic juice contains lipases and nucleases. Lipase acts on fat and converts it into monoglycerides and fatty acids. Nucleases convert nucleic acids into nucleotides.

(88) **(A).** Bile is secreted by liver. Pancreatic juices, secretion of exocrine part of pancreas and succus entricus are secreted by goblet cells of mucosa along with the brush border cells of mucosa. These secretions gets mixed with the partially hydrolysed food in the small intestine.

(89) **(A).** In the mouth, saliva moistens and lubricates the food and chewing (by teeth) breaks the food into smaller pieces. This semi-solid food is moulded into a ball known as bolus by tongue and is pushed into the oesophagus via pharynx.

(90) **(D).** Pancreatic juices can hydrolyse carbohydrates, proteins and nucleic acids.
Starch → Maltose + Isomaltose + Dextrins
Peptones → Dipeptides
Emulsified fat→ Fatty acids + Diglycerides

(91) **(B).** Oesophagus does not secrete any enzyme. It simply passes the food from mouth to stomach by peristalsis.

(92) **(A).** Saliva - the secretion of salivary glands in human constitutes a mixture of water and salts or electrolytes. It's medium is slightly acidic with the pH 6.8. Saliva also contains antibacterial agent, lysozyme.

(93) **(C).** Digestion of proteins begins in the stomach as stomach contains protein digesting enzymes like pepsin, rennin etc. Mouth (saliva) does not contain protein digesting enzymes. Digestion of polysaccharides begins in the mouth as the saliva contains enzymes for them.

(94) **(B).** Gastric juices are the secretion of gastric glands and contains water (98.8%), mucous, inorganic salts, HCl (0.5% conc) and proenzyme pepsinogen, prorennin etc. Gastric amylase and gastric lipase are also present in little amount.

(95) **(B).** When food in the form of bolus reaches into the stomach by involuntary movement of muscular coat from oesophagus, it mixes throughly with the gastric juices present in the stomach. This thoroughly mixed food is called chyme.

(96) **(D).** Intestinal villi :
(a) Possess microvilli.
(b) Increase the surface area.
(c) Supplied with capillaries and the lacteal vessels.

(97) **(B).** Sucrose is hydrolysed into one molecule of glucose and one molecule of fructose by sucrase or invertase enzyme.
Sucrose → Glucose + Fructose.

(98) **(B).** Assimilation is a process of absorbed food nutrients utilisation by the tissues in living beings for energy, growth and maintenance. When nutrients from the food are absorbed, they are transfered into the blood circulation & from the blood, these nutrients are transported to different body cells and tissues, where these nutrients become an integral part of the living protoplasm and provides energy, stimulate growth and repair injured tissues of the body.

(99) **(A).**

(100) **(D).** Absorption of different nutrients from the food carried out by the simple diffusion, osmosis, facilitated transport and by active transport, i.e., absorption of nutrients is carried out by passive, active diffusion and facilitated transport.

(101) **(A).** Absorption of monosaccharides like glucose and galactose occurs by active transport. They are absorbed in the stomach and jejunum. Amino acid are absorbed in the duodenum and jejunum by active transport. While most of the ions (electrolyte), like Na, K, Mg, Fe, P_4 are also actively absorbed throughout the small intestine.

(102) **(B).**

(103) **(C).** The main function of large intestine is absorption of water and elimination of solid wastes. The breakdown of all biomacromolecules like carbohydrates, proteins, fats and nucleic acids takes place in duodenum. A major part of all absorption of digested food takes place in jejunum and ileum. Undigested and unabsorbed substances are passed on to the large intestine for egestion.

(104) **(D).** Absorption of amino acids occur by the active and facilitated transport. But major absorption takes place by the active transport. Absorption of amino acids occur mainly in duodenum and jejunum and parts of the small intestine.

(105) **(B).** Large intestine is the site of absorption for water left in the undigested food product of bacterial digestion like vitamin-B complex, vitamin-K (phylloquinone) and amino acids. They absorbed in the caecum of large intestine.

(106) **(D).** The abnormal and frequent movements of bowl and increase in the frequency, volume, fluid content or liquidity of faeces is called diarrhoea.

Frequent diarrhoea can result in the loss of water (dehydration) and salts or electrolyte imbalance.

(107) (A). Indigestion is a disorder in which the food is not properly digested in the body leading to a feeling of fullness. The causes of this are inadequate enzyme secretion, anxiety, food poisoning, over eating and spicy food.

(108) (A). Due to the deposition of bile pigments, the eyes of patients turns yellow during jaundice.

(109) (C). Gastroporesis, also called delayed gastric emptying, is a disorder that slows or stops the movement of food from the stomach to the small intestine.

EXERCISE-2

(1) (D). ATP production as well as biological molecule production is dependent on the digestion of organic molecules.

(2) (A). Fats have the most potential kcal per gram.

(3) (B). Essential amino acids, fatty acids, vitamins and minerals must be obtained in the diet.

(4) (D). Bulk feeders consume chunks or particles of food; teeth and claws would be advantageous adaptations.

(5) (A). Sac like body plans have one opening for both in take of food and removal of waste products.

(6) (C). All selections except the pancreas are involved in mechanical processing or mixing.

(7) (B). Bile is an alkaline substance produced by the liver and stored in the gall bladder. It is secreted into the small intestine, where it emulsifies fats.

(8) (B). Excess carbohydrates and proteins are stored in the body as fats.

(9) (A). Gastric juice consists primarily of hydrochloric acid, which helps break apart fibrous matter in food and kills bacteria.

(10) (B). The hormone insulin is a main regulator of the glucose (sugar) levels in the blood. Insulin is produced in the pancreas.

(11) (C). Process of digestion starts from mouth. Around 30% of the starch is converted into disaccharides in buccal cavity.

(12) (D). The epithelium of gastric glands (present in stomach) consists of goblet cells that secrete mucus. Mucus forms a coating on the epithelial lining of the stomach and thus protects it from the action of HCl.

(13) (A). Most of the simple sugars (monosaccharides) are absorbed in the stomach and jejunum through the mucosa layer. Around 90% of the water is absorbed in the small intestine through innermost layer cells into the blood capillaries in villi. Alcohol is lipid soluble, its absorption starts in the stomach. However, its absorption is much greater in the small intestine than stomach. Alcohol is absorbed more rapidly in duodenum.

(14) (A). Small finger-like projections responsible for the increase of surface area for absorption of food are prominent in small intestine of human gut. These small projections are better known as villi, which are supplied with a network of blood capillaries and a large lymph vessel called the lacteal.

(15) (D). All the four basic layers in the wall of gut show modifications in different parts of the alimentary canal. E.g., mucosal epithelium has goblet cells which secrete mucus. Mucosa also forms glands in the stomach and crypts in between the bases of villi in the intestine.

(16) (A). Digestion of starch (polysaccharides) starts from the mouth, whereas stomach is the main site of protein digestion. About 30% of starch converts into maltose in oral cavity.

(17) (C). In diarrhoea, the absorption of food is reduced. Diarrhoea is abnormal frequency of bowel movement and increased liquidity of the faecal discharge.

(18) (A). The upper surface of the tongue bear four type of papillae or small projections namely, valate papillae, filiform papillae, fungiform papillae and foliate papillae. Out of them, filiform papillae lacks taste buds but rest of them bear it.

(19) (A). Cholecystokinin is a hormone secreted by the epithelium of entire small intestine and it stimulates the gall bladder to contract to release bile.

(20) **(C).** Caecum, the first part of large intestine, which host symbiotic microorganisms. A finger-like tubular projection called vermiform appendix arises from the caecum.

(21) **(D).** Livers lobules are surrounded by Glisson's capsule.

(22) **(D).** Absorption of fats and fat soluble vitamins are carried out by the simple process of diffusion. Being insoluble in water, fatty acids and glycerol cannot reach the blood stream directly. They are first broken down into water soluble droplets called micelles with the help of bile salts. From micelles, fatty acids, glycerol and vitamins (fat soluble) are absorbed into intestinal cells by diffusion.

(23) **(A).** Enterogastrone, a hormone, secreted by intestinal mucosa, depresses gastric motility and its secretion thus, control the release of food from the stomach into the duodenum.

(24) **(B).** A tooth consists of three region, i.e., crown, neck and root. The exposed part, crown is surrounded by the hardest material of the body. This hardest material is enamel which is the secretion of cells of ameloblast.

(25) **(C).** Large intestine can be divided into three parts for descriptive purposes like caecum, rectum and colon. Ileum is a greatly coiled part of small intestine and it opens into large intestine.

(26) **(B).** The crypts of Lieberkuhn are simple tubular glands that occur throughout the small intestine between the villi. They secrete enzymes and mucus.

(27) **(B).** The secretion of salivary glands is called saliva. Medium of saliva is slightly acidic. The quantity of saliva in an adult is 1000-1500m L/day. Chemically, saliva is a mixture of water and electrolytes. Some enzymes, salivary amylase and lysozyme, (an anti-bacterial agent) are found in saliva.

(28) **(D).** The inflammation of the intestinal tract is the most common ailment due to the bacterial or viral infections.

(29) **(C).** Lacrimal gland is present in the eye and secretes tears. It is not a salivary gland.

(30) **(C).** Carbohydrates and proteins are stored within the body in the form of lipids (fat). Oxidation of lipids produce fatty acids and glycerol. Linoleic acid is a fatty acid, which is not synthesised by human body. It is taken from the food directly.

(31) **(B).** The secretion of goblet cells of mucosa (mucous) along with the secretion of brush boder cells of mucosa in the intestine constitutes intestinal juices or succus entricus. These intestinal juices are rich in enzymes like maltase, dipeptidase, nucleosidaes, sucrase, lactase, enterokinase, aminopeptidase and nucleotidase. The enzymes present in the intestinal juices acts upon the end products of the food, which are then converted into simple absorbable forms.

(32) **(A).** Majority of the electrolytes are absorbed actively into the blood stream throughout the entire small intestine. Amino acids are absorbed in duodenum and jejunum, while calcium and iron are absorbed in the duodenum of the small intestine.

(33) **(C).** HCl of stomach converts prorennin (proenzyme) into its active form rennin. In stomach, rennin acts on casein (milk protein) and converts it into paracasein. In the presence of calcium ions, paracasein is converted into calcium paracaseinate, ultimately leading to milk coagulation.

(34) **(B).** The dentition in human being is diphyodont, heterodont and thecodont. Permanent teeth of mammals are arranged systematically in each jaw. Dental formula provides half of the total number of teeth. Therefore, dental formula is the arrangement of teeth in each half of the upper and lower jaw in the order of incisors, canines, premolars and molars.

(35) **(C).** If we chew a piece of bread long enough, then amylase present in the saliva acts on starch present in the bread and breakdown it into maltose that gives us sweet taste.

(36) **(B).** Four basic layers of human alimentary canal exhibis modification in different parts of alimentary canal.

Mucosa, the innermost lining of gut secretes mucous to lubricate the inner lining of the gut and it is composed of lamina proporia, muscularis mucosa and the epithelium, which forms gastric gland in stomach, and villi and intestinal glands in small intestine.

(37) **(D).** The acidic pH of stomach is maintained by HCl acid which converts pepsinogen into pepsin that acts on protein.

(38) **(B).** The secretion of hepatocytes of liver, pancreas and intestine itself gets mixed with food in small intestine and facilitates the digestion of food in small intestine.

(39) **(B).** The chief cells of gastric glands secrete a small amount of gastric lipase that contributes little to digestion of fat.

(40) **(B).** About 90% of all absorption of nutrients occurs in entire small intestine. Duodenum (proximal part of intestine) is the major site of digestion, while amino acids are absorbed in this small intestine part (95 - 98%).

(41) **(B).** Dental formula represents the number of teeth in each half of the jaw. Dental formula of human beings is $\frac{2123}{2123} \times 2 = 32$.

Number of permanent teeth in human beings are 32 i.e. 8 incisors, 4 canines, 8 premolars and 12 molars.

(42) (D) **(43)** (C)

(44) **(C).** Ileocaecal valve is present at the junction of small intestine and large intestine. The ileocaecal valve normally remains closed, opens briefly to let the contents of small intestine exit and closes again to prevent any backflow of waste materials from the large intestine into small intestine.

(45) **(A).** Bile juice or simply bile is produced by hepatocytes of liver. Bile is collected in interlobular bile duct by bile canals or Hering's canals. The later are joined by bile capillaries, which receives bile from hepatocytes.

Bile from hepatic duct is stored in gall bladder, which is a pear shaped structure and is attached to the posterior surface of the liver.

(46) **(D).** Secretin is a hormone secreted by the epithelium of duodenum. It stimulates gall bladder to secrete bile, inhibits acid secretion in stomach and stimulates the pancreas to secrete bicarbonate ions.

(47) **(B).** In human being, digestion process starts from the mouth, continues in stomach and is completed in small intestine of the gut. About 25-30% of carbohydrates (polysaccharides) are digested or converted into disaccharides (maltose) in the buccal cavity. Rest of the digestion of carbohydrates is completed in small intestine of human alimentary canal.

(48) **(B).** pH of the stomach (1.5 to 2.5) is maintained by HCl which is essential for the protein digesting enzymes to act on proteins. So, if pH of stomach is made 7, then digestion of protein will be affected.

(49) **(B).** Celiac disease is a digestive disorder that damages the small intestine and interferes with absorption of nutrients from food.

(50) **(B).** Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose

(51) **(C).** Small intestine of alimentary canal consists of region/part namely duodenum, colon, rectum. Duodenum (proximal part) is some what C-shaped. The middle jejunum is coiled part and the distal or lower part, ileum is highly coiled. The later part opens into the first part of, large intestine (caecum)

(52) **(B).** Succus entricus or intestinal juices are the secretion of intestinal glands. Brunner's glands in the intestine opens into Crypts of lieberkuhn, which secretes enzymes and mucous. Basically, succus entricus is considered as the secretion of Crypt of Lieberkuhn.

(53) **(D).** Monosaccharides are absorbed in the stomach and middle part of the small intestine (jejunum). Glucose and galactose are absorbed by the active transport while, monosaccharides (fructose and amino acids) absorption takes place by facilitated transport.

(54) **(D).** The stomach has lowest pH of 1.5-2.5 which is maintained by secretion of HCl in it. Liver secretes bile that contain bile salts that act as lipid emulsifiers. Large intestine is mainly involved in absorption of water and elimination of wastes. Proteases also function in the stomach.

EXERCISE-3

(1) **(D).** Kangaroos are herbivores which have long intestinal tracts, only the tiger, a carnivore, has a short intestinal tract.

(2) **(B).** Long term antibiotic treatment will decrease the bacteria that normally inhabit the gut; these bacteria synthesize vitamin K which is necessary for synthesis of clotting factors.

(3) **(C).** Butter is about 80% fat.

(4) **(B).** Adequate fibre intake promotes healthy bowel function.

(5) **(C).** The enzymes in the stomach work best in acidic conditions - in other words, at a low pH.

(6) **(A).** Stomach is located in the upper left portion of abdominal cavity. It is a J-shaped structure and is the widest organ of alimentary canal or human gut. Caecum, a small blind sac host symbiotic microbes and it is a part of large intestine. Oesophagus is a thin, long tube, which extends posteriorly, passing through the neck, thorax and diaphragm and leads to stomach.

(7) **(A).** Maltose is a disaccharide, which gives two molecules of glucose on hydrolysis.

(8) **(D).** Dental formula is the number of teeth on half of upper jaw divided by teeth on half of lower jaw. Rat dental formula is

$$I\frac{1}{1}C\frac{0}{0}PM\frac{0}{0}M\frac{3}{3}$$

(9) **(A).** Lacteals absorbs fatty acids and glycerol in the small intestine of human. Fatty acids and glycerol are insoluble in water so, they cannot be absorbed in blood stream directly. They are first broken down into small, water soluble droplets with the action of bile salts called micelles. The later are absorbed by the intestinal cells where these are resynthesised in the endoplasmic reticulum and are transferred in form of smaller fat droplets-chylomicrons through lacteals. Due to the dilation of intestinal lacteals lymph gets, lost into the lumen of small intestine, which results into lymphopenia, hypoproteinemia, etc.

(10) **(A).** Intestinal juices or succus entericus is the combined secretion of goblet cells of mucosa (mucous) along with the secretion of brush border cells of mucosa. It is rich in variety of enzymes like maltase, lipase, dipeptidase and nucleosidases etc. Partially hydrolysed proteins entering in the intestine from the stomach are converted into dipeptides (two amino acid) by pancreatic juices. Proteins and polysaccharides are converted into disaccharides by amylase present in pancreatic juice. Fats are broken down into diglycerides or monoglycerides by the action of lipase and with help of bile juices. The enzyme present in succus entricus acts on these end products and convert them into simple absorbable forms.
Proteins $\rightarrow$ Dipeptides $\rightarrow$ Amino acids

(11) **(D).** The upper surface of tongue has small projections called papillae. These papillae can be divided into four types: circumvallale or vallale papillae, fungiform papillae, filiform papillae and foleate papillae. Out of four, filiform papillae lacks taste buds, while rest all three have taste buds.
Opening of stomach into duodenum is guarded by pyloric sphincter, while oddi sphincter guards the opening of hepatic ampulla into duodenum.

(12) **(A).** The reflex action during vomiting is controlledby vomit centre in medulla. The feeling of nausea precedes vomiting.

(13) **(A).** Fructose is generally absorbed by facilitated transport. The digestive wastes, solidified into coherent faeces in the rectum initiate a neural reflex causing an urge or desire for its removal.

(14) **(B).** Chylomicrons concerned with the absorption of fats are produced in the epithelial cells of small intestine. They are aggregates of triglycerides, cholesterol and phospholipids, in protein, coated small vesicles. Chylomicrons are small fat droplets, which are released from small intestinal epithelium cells into the lymph and from the lymph to blood stream through lacteals.

(15) **(C).**

(16) **(B).** Process of digestion starts in the mouth, continues in stomach and is completed in small intestine. In buccal cavity or oral cavity, the digestion of carbohydrates gets started and 30% of polysaccharides present in the food gets converted into disaccharides (maltose). Rest 70% of carbohydrates are completely digested in the small intestine.

(17) **(A).** Oxyntic (parietal) cells of gastric glands secrete HCl which forms the part of gastric juice. HCl makes the pH of gastric juice between 2-3. Beta cells of islets of Langerhans produce insulin that increases blood sugar level. Kupffer cells present in the liver are phagocytic cells that eat out worn out WBCs, RBCs and bacteria. Sweat glands secrete sweat that evaporates for cooling.

(18) **(C).** There are three pair of salivary gland in human being. They are, a pair of parotids gland, a pair of sublingual glands and a pair of submaxillary gland. Zymogen cell are one type of gastic glands secretes zymogens or proenzyme - pepsinogen and prorennin along with, small amount of gastric lipase and amylase.

(19) **(C).** Amylase hydrolyzes starch to maltose, isomaltose and α-dextrins. Hydrochloric acid activates pepsinogen to pepsin. Rennin coagulates the milk protein casein.

(20) **(A).** Pancreatic juice contains trypsinogen, chymotrypsinogen, carboxypeptidase (proenzyme) and sodium bicarbonate. Pancreatic lipase, pancreatic-amylase, DNase and RNase are also present in little amount in gastric juices.

(21) **(D).** An amylase is an enzyme that catalyses the hydrolysis of starch into sugars.
Lactase, also called lactase-phlorizin hydrolase, enzyme found in the small intestine of mammals that catalyzes the breakdown of lactose (milk sugar) into the simple sugars glucose and galactose.
Maltase is an enzyme located in on the brush border of the small intestine that breaks down the disaccharide maltose.
Invertase is an enzyme that catalyzes the hydrolysis (breakdown) of sucrose (table sugar).

(22) **(C).** α-amylase is found in pancreatic juices. Enzyme amylase converts starch into disaccharides, like maltose, isomaltose and dextrins in the small intestine.
Starch → Maltose (disaccharides)
Equation (A) is incorrect as stomach do not contains any fat emulsifying agent.
In equation (B) is incorrect as proteins are converted to dipeptides, i.e. two amino acids by the enzymes trypsin and equation (D) triglycerides are converted to diglycerides and fatty acids by lipase enzyme.

(23) (C) **(24)** (D) **(25)** (D)
(26) (C) **(27)** (D)

(28) **(D).** Gastric glands are numerous, microscopic, simple tubular glands present in the wall of the stomach. They have three common types of gland cells: (i) Peptic (= chief or zymogen) cells that are usually basal in location and secrete digestive enzymes pepsinogen and prorennin (proenzymes) and small amounts of gastric amylase and gastric lipase. (ii) Parietal (= oxyntic) cells secrete HCl and Castle's intrinsic factor. (iii) Mucous (= Goblet) cells secrete mucus.

(29) **(C).** Ruminant animals such as cattle, buffalo, sheep, goat and camel have a compound stomach, which consists of four chamber, viz, rumen, reticulum, omasum and abomasum. Rumen is the first and the largest of the four chambers. Rumen and reticulum harbour numerous bacteria and protozoa, which carry out extensive fermentation of cellulose.

So, these two chambers function as sites for cellulose digestion in ruminantts. The gastric juice containing enzymes and HCl is secreted only by the fourth chamber i.e., Abomasum.

(30) **(B).** Acidic medium activates the action of gastric juice. HCl maintains a strong acidic pH of about 1-2 in the stomach. At this acidic pH inactive pepsinogen is spontaneously hydrolysed to active pepsin and inactive pro-rennin is convert to active rennin. Pepsin and rennin digest proteins to peptones and proteoses. In addition, HCl helps to kill and inhibit the growth of bacteria and other harmful organisms that may enter in the stomach along with the food.

(31) **(A).** Chewing food helps in ptyalin action (ptyalin or salivary amylase is a starch hydrolysing enzyme present in the saliva of human), because it mixes the food with saliva. It also breaks food particles into smaller particles with greater surface area exposed to enzyme action. It also starts starch digestion in mouth.

(32) **(B).** Pancreas is the second largest digestive gland in our body. As an exocrine gland, it secretes pancreatic juice while as an endocrine gland, it secretes hormones insulin, glucagon and somatostatin.

(33) **(B).** Vermiform appendix, a slightly coiled tube of about 8cm is an outgrowth of caecum. Its wall contains prominent lymphoid tissue. It is thought to be vestigial. It has no apparent digestive function.

(34) **(D).** Deglutition (swallowing) starts as a voluntary action in the mouth and then continues as an involuntary action. Skeletal muscle surrounds the upper third of the oesophagus and smooth muscle surrounds the lower two-thirds.

(35) **(B).** The human small intestine is the longest (6.25 m long) part of alimentary canal. Villi present in the small intestine increase its surface area for absorption as most of the absorption occurs in small intestine.

(36) **(C).** A dental formula consists of eight numbers, four above and four below a horizontal line. The numbers represent (from left to right) the number of incisors, canines, premolars and molars in either half of the upper and lower jaws e.g., the dental formula of man is $\frac{2123}{2123}$.

We have seen that dental formula is used to represent heterodent teeth which are present in mammals only. It cannot be used to represent dentition of vertebrates other than mammals as they have homodont teeth.

EXERCISE-4

(1) **(B).** Glycerol and fatty acids are absorbed in jejunum by diffusion into intestinal cells where they are converted into chylomicrons. Cholesterol is also absorbed by simple diffusion in small intestine. Maltose is broken into glucose and galactose which are absorbed by active transport into small intestine. Fructose is absorbed by facilitated diffusion. Amino acids are also absrobed in small intestine, some by active transport and some by facilitated diffusion.

(2) **(C).** The initial step in the digestion of milk in human is carried out by rennin.

(3) **(B).** Fructose is absorbed with the help of the carrier ions like Na^+. This mechanism is called facilitated transport.

(4) (B)

(5) **(A).** Dental formula for milk teeth is $\frac{2102}{2102}$ so premolars are absent.

(6) **(A).** Succus entericus is intestinal juice contains maltase, lipase, nucleosidase. Nucleases are the enzymes of pancreatic juice.

(7) **(B).** In stomach, gastric acid (HCl) is secreted by parietal cells of gastric gland.

(8) **(D).** Sphincter of Oddi guards the opening of hepatopancreatic duct into the duodenum.

(9) **(B).**

* Kupffer-cells are phagocytic cells of liver.
* Zymogen cells are enzyme producing cells.
* Paneth cell secretes lysozyme which acts as anti-bacterial agent.
* Argentaffin cells are hormone producing cells.

(10) **(C).** Total number of teeth in human child = 20.

Premolars are absent in primary dentition.

(11) **(D).** Rennin and Pepsin enzymes are present in the gastric juice. Maltase is present in the intestinal juice.

(12) **(D).** Parietal or oxyntic cell is a source of HCl and intrinsic factor. HCl converts iron present in diet from ferric to ferrous form so that it can be absorbed easily and used during erythropoiesis.

Intrinsic factor is essential for the absorption of vitamin B_{12} and its deficiency causes pernicious anaemia.

(13) **(B).** In humans, dentition is

Thecodont : Teeth are present in the sockets of the jaw bone called alveoli.

Diphyodont : Teeth erupts twice, temporary milk or deciduous teeth are replaced by a set of permanent or adult teeth.

Heterodont dentition : Dentition consists of different types of teeth namely incisors, canine, premolars and molars.

(14) **(C).** Crypts of Lieberkuhn are present in small intestine. Glisson's capsule is present in liver. Islets of langerhans constitutes the endocrine portion of pancreas. Brunner's glands are found in submucosa of duodenum.

(15) **(B).** Goblet cells secrete mucus and bicarbonates present in the gastric juice which plays an important role in lubrication and protection of the mucosal epithelium from excoriation by the highly concentrated HCl.